Comprehensive Fisheries Survey Results and Management Plan of the Cloverleaf Chain of Lakes (WBIC 299000) Shawano County, Wisconsin, 2017

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Executive Summary:

The Cloverleaf Chain of Lakes consists of a group of three lakes totaling 316 acres in south central Shawano County. A spring fyke netting and spring electrofishing survey were conducted in 2017 to evaluate the current status of the fishery and guide fisheries management recommendations moving forward. The Cloverleaf Chain supports populations of four popular gamefish species including muskellunge, northern pike, walleye, and largemouth bass. Muskellunge were found in moderate densities with several large individuals captured. Stocking will be necessary to maintain the muskellunge population as no evidence of natural reproduction has been observed. Numbers of northern pike have continued to decline and size structure and condition remain poor. Large fingerling northern pike were stocked in 2014 and 2017 to hopefully increase numbers of northern pike. The large fingerling walleyes that were stocked in 2013 and 2015 have resulted in two year classes. Walleyes between 10.5 – 13.5 inches and 15 – 17 inches were captured with both gears. Placing a more restrictive walleye regulation such as an 18-inch minimum length limit and daily bag limit of three could help enhance the quality of the walleye fishery in the Cloverleaf Chain. Largemouth bass numbers have increased since the last survey but few large individuals were captured. Limited prime largemouth bass habitat combined with high number of bass are likely driving the slow growth. Panfish numbers have decreased since previous surveys but densities still remain moderate – high and few large individuals of any panfish species were captured. Hopefully reduced densities will result in faster growth rates and improved size structure in the future. Additionally, the special panfish regulation (25 fish daily bag w/only 5 fish >7”) put in place in 2016 will help reduce harvest of some of the largest bluegill in the population and hopefully increase harvest of smaller bluegills, further enhancing size structure. Additional habitat restoration opportunities should be assessed in the form of fish sticks (natural woody habitat) and shorelands with native emergent and riparian vegetation to provide additional fish habitat in the Cloverleaf Chain of Lakes.

Introduction:

The Cloverleaf Chain of Lakes consists of a group of three interconnected lakes located just northeast of the town of Embarrass, in south-central Shawano County, very near the Waupaca County border. The three lakes that make up the Cloverleaf Chain of Lakes are Round, Grass, and Pine Lakes. Round Lake is the smallest lake at 26.4 acres and is the western start of the Chain of Lakes. Round Lake is a deep headwater lake that has some springs (WDNR 2017c). Round lake is essentially a large deep bowl with a mean depth of 26 feet, a maximum depth of 40 feet, with the bottom being almost entirely muck (WDNR 2017c). The middle lake in the Chain is Grass Lake. Grass Lake is 80.6 acres and is the deepest of the three lakes with a mean depth of 14 feet and a maximum depth of 52 feet (WDNR 2017a). The bottom substrate of Grass Lake consists of a mix of sand, gravel, rock, and muck (WDNR 2017a). The largest of the three lakes is Pine Lake which has a surface area of 208.6 acres. The bottom substrate of Pine Lake is primarily gravel and rock with some sand and muck (WDNR 2017b). Pine Lake is the shallowest lake with a mean depth of only eight feet and a maximum depth of 35 feet (WDNR 2017b). In total, the three lakes add up to 316 acres. A dam and outflow to the Embarrass River along the southern shoreline of Pine Lake controls water levels in the Cloverleaf Chain of Lakes.

The Cloverleaf Chain of Lakes has supported a diverse mix of coolwater and warmwater fish species through time. Predatory gamefish that are present in the Cloverleaf Chain include muskellunge, *Esox masquinongy*, walleye, *Sander vitreus*, northern pike, *Esox lucius*, and largemouth bass, *Micropterus salmoides*. Panfish species that are present in the Cloverleaf Chain of Lakes include bluegill, *Lepomis macrochirus*, pumpkinseed, *Lepomis gibbosus*, yellow perch, *Perca flavescens*, and black crappie, *Pomoxis nigromaculatus*. A plethora of other fish species have been captured in previous surveys including banded killifish, *Fundulus diaphanous*, black bullhead, *Ameiurus melas*, blackchin shiner, *Notropis heterodon*, bluntnose minnow, *Pimephales notatus*, bowfin, *Amia calva*, brook silverside, *Labidesthes sicculus*, brown bullhead, *Ameiurus nebulosus*, common carp, *Cyprinus carpio*, common shiner, *Luxilus cornutus*, golden shiner, *Notemigonus crysoleucas*, green sunfish, *Lepomis cyanellus*, Iowa darter, *Etheostoma exile*, lake chubsucker, *Erimyzon sucetta*, mimic shiner, *Notropis volucellus*, rock bass, *Ambloplites rupestris*, tadpole madtom, *Noturus gyrinus*, white sucker, *Catostomus commersonii*, and yellow bullhead, *Ameiurus natalis*.

As a public fishery, the Wisconsin Department of Natural Resources (WDNR) has been managing the Cloverleaf Chain of Lakes for over 75 years. The WDNR conducted their first recorded fisheries survey of the Cloverleaf Chain in 1946 when a netting survey was conducted on August 10 and 11 (Williamson 1946). Bluegill, black crappie, largemouth bass, yellow perch, rock bass, sunfish spp., sucker spp., and bullhead spp. were all captured in the 1946 survey (Williamson 1946). Conclusions from that survey were that the Chain was overpopulated with bluegills, rock bass, and sunfish (Williamson 1946). Additional fisheries surveys have taken place in 1960, 1968, 1970, 1972, 1976, 1977, 1978, 1980, 1981, 1982, 1984, 1985, 1987, 1988, 1989, 1994, 2000, 2005, 2008, 2009, 2013, and 2014. Fyke nets, mini fyke nets with turtle exclusions, and boomshockers have all been used to sample the Cloverleaf Chain of Lakes. The most recent paired surveys in back to back years in 2008 and 2009 and again in 2013 and 2014 represent comprehensive surveys aimed at evaluating the entire fishery.

Stocking has long been a tool used by fisheries managers to manipulate the fisheries in the Cloverleaf Chain of Lakes. The first recorded stockings took place in 1939 when sunfish spp., yellow perch, largemouth bass, black crappie, bullhead spp., and bluegill were all stocked (Table 1). Walleyes were initially stocked in 1940 but stocking has shown little success through time, and walleyes have not been able to create a self-sustaining population (Table 1). Northern pike were initially stocked in 1942, with several additional stockings taking place in the 1940s and 1950s (Table 1). For the most part, northern pike have maintained a population through natural reproduction as only three stockings have taken place since 1959, one in 1989, 2014, and 2017 (Table 1). Muskellunge were first stocked into the Chain in 1962 to create an additional fishing opportunity for this species within the region (Table 1).

Muskellunge have perhaps been the species that has shown the most success since being stocked into the Cloverleaf Chain of Lakes. Even brown trout were stocked once in 1952 under the hope that they could find cold enough water in some of the deeper holes to survive (Table 1). In all, stocking of one species or another has taken place in most years since 1939 (Table 1).

Despite the majority of the shoreline of the Cloverleaf Chain of Lakes being highly developed, a significant effort has been made by many organizations to preserve and enhance the natural integrity and fisheries of the Cloverleaf Chain of Lakes. In 2003, the WDNR completed a sensitive areas survey of all three lakes and proposed that six areas among the Cloverleaf Chain of Lakes be classified as sensitive areas because they offer critical or unique fish and wildlife habitat or offer water quality or erosion control benefits to the waterbody (Olson 2003). Within the report, the WDNR also provided whole lake management recommendations such as eliminate chemical fertilizers on lawns as well as management recommendations for each individual sensitive area (Olson 2003). Shortly after the sensitive areas survey was completed, the Cloveleaf Lakes Protective Association partnered with NES Ecological Services to complete a shoreland restoration project and prepare a shoreland restoration guide for lake residents (NES Ecological Services 2011). The purpose of the shoreland restoration guide was to educate residents about the interactions that occur between a lake and its shoreline, provide shoreland restoration options and recommendations, and provide examples of completed shoreland restoration projects (NES Ecological Services 2011).

Steps were then taken to preserve the natural integrity of Gibson Island, a large natural island that separates Grass and Pine Lakes, when the township and Protective Association partnered to purchase the island. Gibson Island also was one of the WDNR designated sensitive areas, meaning protecting the island would ensure critical habitat was also protected. Wanting to do more, the town of Belle Plaine, the Cloverleaf Lakes Protective Association, and the Belle Plaine Sportsman's Club received a Healthy Lakes Grant from the WDNR to implement best management practices such as completing a fish sticks project around Gibson Island and along the south shore of Round Lake near the connection with Grass Lake, native plantings along shorelines, and rain gardens (WDNR 2017d). These best management practices were implemented between 2014 and 2017 (WDNR 2017d). Several private organizations, including the Figure 8 Musky Club, the Cloverleaf Lakes Protective Association, The Embarrass River Conservation Club and the Belle Plaine Sportsman's Club have also worked to enhance the fisheries within the Cloverleaf Chain of Lakes by purchasing fish from private hatcheries that were stocked into the Cloverleaf Chain of Lakes.

The objective of sampling efforts in 2017 were to complete a comprehensive survey of the fish community within the Cloverleaf Chain of Lakes. More specifically, relative abundance, population estimates, size structure, and growth were quantified for different gamefish and panfish species found within the Cloverleaf Chain of Lakes. Furthermore, a second year of fyke netting will be conducted in spring 2018 to serve as the recapture survey for a muskellunge population estimate.

Methods:

Field Sampling:

All field sampling was conducted following WDNR sampling protocols as laid out in the Department's Lake Sampling Procedure Manual (Simonson et al. 2008). Sampling began on the Cloverleaf Chain of Lakes with a spring fyke netting survey. The objective of spring fyke netting surveys is to capture, measure, and mark adult walleyes, northern pike, and muskellunge. Spring fyke netting surveys typically begin shortly after ice out because northern pike begin spawning when water temperatures are 35 – 40 °F and walleyes begin spawning when water temperatures are 38 – 44 °F (Becker 1983). Muskellunge typically spawn just after northern pike when water temperatures are 49 – 60 °F (Becker 1983). For spring fyke netting surveys, fyke nets are placed in locations that are thought to have good walleye, northern pike, or muskellunge spawning habitat or may be travel corridors for these species on their way to spawning locations. Muskellunge and northern pike often spawn in similar habitat so net locations are often similar when targeting these species and both species are commonly caught in the same nets at the same time.

The first fyke nets were set on the Cloverleaf Chain of Lakes on April 3rd, when nets were set at locations 1 – 5 in Grass Lake (Figure 1). Three additional nets were set on April 4th at locations 6 – 8 in Round Lakes and Grass Lakes (Figure 1). The fyke net at location #8 was pulled and moved to location #9 on April 10th due to low catches at location #8 (Figure 1). All nets were removed from the Cloverleaf Chain of Lakes on April 14th. Water temperatures throughout the fyke net survey average 45.6 °F and ranged from 42 – 50 °F. Once a net is set, it is allowed to fish for approximately 24 hours (i.e., one net night), meaning that all nets are checked, fish are removed, and the net is set back in place every day. Fyke nets were set for a total of 85 net nights throughout the duration of the fyke netting survey.

When checking nets each day, all fish are removed from the nets and placed in a livewell. All walleye, northern pike, and largemouth bass are measured for total length, weighed, sexed if possible, examined for fin clips that could indicate stocking origin or a recapture of this survey, given a small partial top caudal fin clip if this fin clip is not observed (i.e., a mark that indicates that particular individual was captured in this spring fyke netting survey), and released at a location away from the nets so they don't swim right back into the net again. All muskellunge go through the same process as walleye, northern pike, and largemouth bass, except Passive Integrated Transponder (PIT) tags are used in place of fin clips to mark muskellunge. Therefore, all muskellunge are scanned for a PIT tag using a digital PIT tag reader and given a PIT tag in the back muscle just under the dorsal fin if one is not found. All panfish are measured for length and then released at a location away from the net. If a significant amount of panfish are captured throughout the survey, a subsample of each species may be measured for length. All panfish not measured are counted and then released. Additionally, a subsample of 5 – 10 bluegill and black crappie in each ½ inch length bin (e.g., 4.0 – 4.5 inches) were collected and otoliths were extracted for age and growth analysis. All other species are counted and released at a location away from the net so they are not immediately captured again.

The WDNR conducted a one night spring electrofishing II survey of the Cloverleaf Chain of Lakes on May 18, 2017. The primary objective of spring electrofishing II surveys is to count and measure adult bass and panfish. Two different station types are used during spring electrofishing II surveys: 1.) a gamefish station in which only largemouth bass, northern pike, walleye, and muskellunge are netted and placed in a livewell for collection of scientific data; and 2.) a panfish/dip all station in which all fish that are encountered are netted and placed in a livewell for collection of scientific data (Simonson et al. 2008). Following completion of an individual station, all netted fish are identified, counted, and all gamefish and panfish are measured for total length. If a significant amount of panfish were netted during a single panfish/dip all station, three random scoops of panfish were collected from the livewell and all individuals captured in those three scoops were measured. The rest of the panfish that were captured during the station were identified and counted (Simonson et al. 2008). All other species are counted and released.

Five different stations encompassing the entire shorelines of Grass and Pine Lakes were sampled during the spring 2017 electrofishing survey of the Cloverleaf Chain of Lakes (Figure 2). Three stations totaling 3.23 miles of shoreline (i.e., Station A = 1 mile, Station C = 1.5 miles, and Station E = 0.73 miles) were gamefish stations (Figure 2). Two stations totaling one mile of shoreline (i.e., Station B = 0.5 miles; Station D = 0.5 miles) were panfish/dip all stations (Figure 2). None of the shoreline of Round Lake was sampled because the electrofishing boat is not able to fit through the culvert that connects Round Lake and Grass Lake.

Data Analysis:

The total number of all species captured in the spring 2017 fyke net survey and electrofishing survey as well as mean, minimum, and maximum lengths, catch per unit effort (CPUE), proportional stock density (PSD), and length frequency histograms were calculated/created for largemouth bass, northern pike, walleye, muskellunge, bluegill, pumpkinseed, black crappie, and yellow perch captured in each sampling gear. Relative weights were calculated for northern pike captured in spring fyke netting surveys. Catch per unit effort refers to the number of a given species captured per unit distance or time. For netting surveys, CPUE is typically quantified as the number of a given fish species captured per net night, or the equivalent of the 24-hour time period that nets are allowed to fish in between checks of the nets. For electrofishing surveys, CPUE is typically quantified as the number of a given fish species captured per mile of shoreline sampled. Catch per unit effort is used as an index to represent relative abundance and can be used to show changes in population density through time. For electrofishing surveys, CPUE can also be calculated based on the number of a given species that is a specified length or larger (e.g., bluegill ≥ 7 inches) that are captured per mile of shoreline sampled. Proportional stock density is an index used to describe the size structure of a given species. It is calculated by dividing the number of quality size and larger individuals captured by the number of stock size and larger individuals captured. Quality and stock lengths for all species were taken from Anderson and Neumann (1996). Proportional stock density (PSD) values of 40-60 typically describe a balanced population, meaning a population can produce harvestable size fish nearly every year (Swingle 1950). Therefore, balanced fisheries have a mix of both harvestable size fish as well as smaller fish that will grow to be a harvestable size in the next couple of years. Relative stock density (RSD) values were also calculated for some species by dividing the number of fish captured larger than the specified length (e.g., ≥ 7.0 inches for bluegill) by the number of stock length and larger fish of a given species. Length frequency histograms are a graphical representation of the number or percentage of fish of a given species captured by size intervals. Half inch size intervals were used for all panfish length frequency histograms whereas one inch size intervals were used for all gamefish length frequency histograms. Relative weights were calculated for northern pike based on slope and intercept parameters for standard weight equations presented in

Anderson and Neumann (1996). Relative weights provide an indication of the plumpness or condition of fish. A relative weight of 93 means a fish has an average plumpness compared to other fish of the same length. Relative weight values above and below 93 mean a fish more plump or skinnier than an average fish of the same length, respectively.

A Schnabel population estimate using multiple mark and recapture events was used to estimate the size of the northern pike population in the Cloverleaf Chain of Lakes in 2017. Numbers of marked and unmarked northern pike from each days fyke netting survey were used to get an estimate of the total number of adult northern pike in the Cloverelaf Chain of Lakes. Otoliths collected from bluegill and black crappie in 2017 were embedded in an epoxy resin and a thin section was taken out of the center of each otolith. Two readers estimated the age of each bluegill and black crappie. Mean ages at lengths were calculated for two size classes of bluegills (i.e., 5.5 – 6.4 inches and 6.5 – 7.4 inches) and black crappie (i.e., 7.5 – 8.4 inches and 8.5 – 9.4 inches) that were sizes desired by anglers. Mean ages at lengths were used to evaluate how long it takes for these two species to reach harvestable size. Furthermore, mean lengths at age were estimated for bluegill and black crappie using otoliths collected from all sizes classes of individuals captured.

Where possible, results from the 2017 survey were compared to results from historical surveys to show fisheries trends through time within the Cloverleaf Chain of Lakes. Also, results from the 2017 comprehensive survey were compared to sampling data collected throughout the state of Wisconsin to evaluate how the fishery in the Cloverleaf Chain of Lakes compares to other waterbodies throughout the state of Wisconsin. Furthermore, muskellunge become very trap shy after getting captured in a fyke net, meaning two consecutive years of sampling is required to get a muskellunge population estimate using mark recapture. Therefore, the spring 2017 fyke net survey will act as a marking event, and a second spring fyke netting survey in 2018 will act as a recapture event to get a population estimate for muskellunge in the Cloverleaf Chain of Lakes.

Results:

Fish Community:

Eighteen different fish species were captured during 2017 spring fyke netting or spring electrofishing surveys of the Cloverleaf Chain of Lakes (Table 2; Table 3). Common gamefish species encountered during surveys include northern pike, largemouth bass, muskellunge, and walleyes, whereas common panfish species include bluegill, black crappie, pumpkinseed, and yellow perch (Table 2; Table 3). One invasive fish species, the common carp, was captured during spring electrofishing surveys (Table 3). However, only two common carp were captured in over four miles of electrofishing, likely indicating low numbers of common carp in the Cloverleaf Chain of Lakes (Table 3). Additionally, four lake chubsucker, a fish species of Special Concern in the state of Wisconsin, were captured during spring fyke netting surveys (Table 2).

Gamefish species:

Northern Pike:

A total of 109 northern pike were captured during spring fyke netting surveys, resulting in a CPUE of 1.3 northern pike per net night (Figure 3). Furthermore, the estimated number of adult northern pike in the Cloverleaf Chain was 268, or 0.85 northern pike per acre (Table 4). Netting CPUE combined with population estimates indicated a low to moderate density of northern pike in the Cloverleaf Chain. Additionally, CPUE estimates of northern pike in spring fyke netting surveys have been declining through time over the last decade, as northern pike CPUE was 3.0 per net night in 2008, 2.5 per net night in 2013, and only 1.3 per net night in 2017 (Figure 3). Large fingerling northern pike were stocked in 2014 and 2017 to try to enhance the northern pike population (Table 1).

The northern pike population in the Clover Leaf Chain has historically been dominated by smaller individuals, and results from 2017 surveys have shown that this trend is continuing. The mean size of northern pike captured in the spring fyke netting survey was only 16.6 inches, with pike ranging in size from 9.5 – 31.0 inches being captured. Additionally, 19 northern pike were captured in spring electrofishing surveys, with the mean size being only 15.3 inches (Table 4). Northern pike PSD values from spring 2017 fyke netting and electrofishing surveys were 16 and 9 respectively (Figure 5; Figure 6). Since 1980, northern pike PSD values have ranged between 5 – 20, indicating populations dominated by individuals < 21.0 inches, although PSD values have been increasing in the last couple of surveys (Figure 5). Length frequency histograms show that the majority of northern pike captured in spring fyke netting or electrofishing surveys in 2017 were between 13.0 – 20.0 inches (Figure 7; Figure 8). Furthermore, northern pike captured in the 2017 fyke netting survey were fairly skinny/in poor condition having a mean relative weight of approximately 80 with most northern pike having a relative weight below 90 (Figure 9). Northern pike relative weights in 2017 were similar to the previous two comprehensive surveys (i.e., 2008 and 2013) when mean relative weights were approximately 83 in both surveys.

Walleye:

Walleye were also found in low abundance in the Cloverleaf Chain. Only 17 walleyes were captured in spring fyke netting surveys for a CPUE of 0.2 per net night (Figure 3). Walleye CPUE from the spring fyke netting surveys was low when compared to statewide data, ranking out in the 8th percentile statewide. Furthermore, walleye fyke net CPUE was similar to previous years fyke netting surveys when CPUE averaged 0.3 per net night in 2008 and 0.1 per net night in 2013 (Figure 3). Interestingly, 35 walleyes were captured during the spring largemouth bass/panfish electrofishing survey for a CPUE of 8.3 per mile of electrofishing (Figure 4). No walleyes were captured in 2008 or 2013 electrofishing surveys of the Clover Leaf Chain of Lakes (Figure 4).

Sizes of walleyes captured in 2017 were very different than in previous years surveys. The average size of walleyes captured in spring 2017 fyke netting survey was 13.8 inches with a range from 10.6 – 25.8 inches and the average size of walleye captured in spring electrofishing surveys was 12.0 inches with a range from 10.5 – 16.7 inches (Table 3; Table 4). Walleye PSD values from 2017 fyke netting and electrofishing surveys were 31 and 6 respectively (Figure 5; Figure 6), and the majority of walleyes captured by either gear were between 10 – 16 inches (Figure 7; Figure 8). Walleye PSD values in all fyke netting surveys between 1980 and 2013 were between 80 – 100, indicating a walleye population dominated by larger, harvestable size walleyes (Figure 5). The walleye population in the Cloverleaf Chain appears to be maintained solely through stocking and the walleyes that were between 10 – 14 inches were likely 2 years old from the 2015 large fingerling stocking with the 15 – 17 inch walleyes likely being four year olds from the 2013 large fingerling stocking (Table 1). Large fingerling walleyes were also stocked into the Cloverleaf Chain in 2017 as part of the Wisconsin Walleye Initiative (Table 1).

Muskellunge:

Muskellunge were captured in moderate densities with 42 total captures in 2017 spring fyke netting surveys for a CPUE of 0.5 muskies per net night (Figure 3). A musky CPUE of 0.5 per net night ranks out in the 55th percentile when compared to catch rates throughout the state of Wisconsin. Catch rates of muskies have been declining over the past decade as 1.8 muskies per net night were captured in 2008 and 0.6 muskies per net night were captured in 2013 (Figure 3). A recent decrease in stocking rate could explain the decline in musky catch rates. From 2000 – 2008, between 340 and 640 large fingerling muskies were stocked in even years, with three of those years receiving 638 – 640 large fingerling muskies (Table 1). Muskies have only been stocked three times since 2008, in 2010, 2014, and 2017, and at a much lower rate with only 193 – 316 muskies being stocked in any one year since 2010 (Table 1). The reduction in stocking was aimed to reduce densities of muskellunge in the Cloverleaf Chain. A second fyke netting survey will take place in 2018 to serve as the recapture survey to get a musky population estimate.

Despite its small size, muskellunge grow to very large sizes in the Cloverleaf Chain of Lakes. The average size of muskies captured in the spring 2017 fyke netting survey was 39.7 inches with a range from 33.3 inches to 47.4 inches (Table 3). Furthermore, 13 muskies over 40 inches were captured during spring fyke netting (Figure 7). Since 1980, muskellunge PSD values have been above 46 in every fyke netting survey conducted, and have been above 75 in four fyke netting surveys including a high of 97 in the spring 2017 fyke netting survey. This indicates that muskellunge have the potential to consistently reach large sizes in the Cloverleaf Chain (Figure 6). Future muskellunge management will continue to be aimed at maintaining a low density fast growing muskellunge population with the potential to regularly produce fish over 40 inches.

Largemouth Bass:

The Cloverleaf Chain of Lakes supports a high largemouth bass population. A total of 174 largemouth bass were captured in spring largemouth bass/panfish electrofishing surveys, resulting in a CPUE of 41.1 largemouth bass per mile of shoreline (Figure 4). This is a fairly high density of largemouth bass, ranking out in the 81st percentile when compared to other lakes throughout the state of Wisconsin. Additionally, largemouth bass electrofishing CPUE in 2017 was slightly higher than in the previous two electrofishing surveys (i.e., 2008 and 2013), when electrofishing CPUEs were 31.9 and 32.8 (Figure 4). Largemouth bass catches in the spring 2017 fyke net survey were low, averaging just 0.2 per net night (Figure 3). However, fyke netting is not a preferred method to sample largemouth bass because bass do not congregate in specific areas to spawn, making results from electrofishing surveys more representative of the population.

Largemouth bass size structure in the Cloverleaf Chain is moderate with the mean size of largemouth bass captured in spring electrofishing surveys being 10.5 inches with a range from 4.1 – 16.4 inches (Table 3). Mean size of largemouth bass captured in the 2017 fyke netting survey was slightly smaller at 9.2 inches (range = 5.8 – 16.5 inches; Table 2), and length frequency distributions from both fyke netting and electrofishing showed a fairly even distribution of largemouth bass in all size classes between 5 – 16 inches with strong year classes between 6 – 7 inches and 12 – 14 inches (Figure 7; Figure

8). Largemouth bass PSDs have been fairly stable through time, ranging between 40 – 60 in most electrofishing and fyke netting surveys that have taken place since 1980. This represents a balanced population comprised of an even mix of largemouth bass that are sizes desired by anglers as well as smaller individuals that will grow to be sizes desired by anglers in the future (Figure 5; Figure 6). Five largemouth bass ≥ 14.0 inches were captured per mile of electrofishing, which ranks out in the 67th percentile when compared to statewide data. Despite a moderate density of harvestable size largemouth bass, few largemouth bass > 16.0 inches were captured. Previous surveys have shown that largemouth bass growth is slow to moderate in the Cloverleaf Chain. Continued high density and slower than average growth likely explain why few bass ≥ 16.0 inches are captured.

Panfish Species:

Bluegill:

The Cloverleaf Chain continues to support a moderate/high bluegill population as 1,300 bluegill were captured in the spring 2017 fyke netting survey for an average of 15.3 bluegill per net night (Table 2; Figure 10). Bluegill catch rates in the spring 2017 fyke netting survey were lower than in the previous two fyke netting surveys when catch rates were 43.0 and 30.5 bluegill per net night (Figure 10). Despite declines in bluegill catch rates through time, a catch rate of 15.3 bluegill per net night (i.e., the catch rate in the spring 2017 fyke net survey) still ranks out in the 60th percentile when compared to catch rates throughout the state of Wisconsin, indicating a moderate density of bluegill in the Cloverleaf Chain. One hundred seven bluegill were captured in the spring 2017 largemouth bass/panfish electrofishing survey for a catch rate of 107 bluegill per mile of electrofishing (Table 3; Figure 11). Catch rates in the 2017 spring electrofishing survey were similar to those observed in 2013, but only half of what was observed in 2008 (Figure 11). A catch rate of 107 bluegill per mile of electrofishing ranks out in the 56th percentile when compared to catch rates throughout Wisconsin, again indicating a moderate density of bluegill in the Cloverleaf Chain.

Similar to bluegill densities, results from 2017 surveys have shown the bluegill size structure is also moderate in the Cloverleaf Chain of Lakes. The mean size of bluegill captured in the spring fyke netting survey and spring electrofishing survey were 5.8 and 5.9 inches, respectively (Table 2; Table 3). Additionally, sizes of bluegill captured in the spring fyke netting survey ranged from 3.6 – 8.6 inches and bluegill captured in the spring electrofishing survey ranged from 2.5 – 7.6 inches (Table 2; Table 3; Figure 14; Figure 15). Furthermore, bluegill PSD from the spring fyke netting survey was 48 and bluegill PSD from the spring electrofishing survey was 52 (Figure 12; Figure 13). This indicates a relatively even balance of both harvestable size bluegill as well as bluegill that will grow to be harvestable size in the next couple of years. A bluegill PSD of 42 in spring fyke netting surveys ranks out in the 42nd percentile statewide, whereas as a PSD value of 52 in the spring electrofishing survey ranks out in the 79th percentile, also indicating a moderate size structure of bluegill in the Cloverleaf Chain. Bluegill PSD values in both the spring fyke netting and spring electrofishing surveys were very similar to previous years surveys (Figure 12; Figure 13).

Despite having PSD values of 42 in the spring fyke netting survey and 52 in the spring electrofishing survey, large bluegills remain rare in the Cloverleaf Chain. Bluegill RSD – 7 (e.g., percent of stock length and larger bluegill that are also ≥ 7.0 inches) values were only 10 from the spring fyke netting survey and only 8 from the spring electrofishing survey. This indicates that only a small percentage of the bluegill population is ≥ 7.0 inches in length. Bluegill ≥ 8.0 inches were almost non-existent in the Cloverleaf Chain. However, nine bluegill ≥ 7.0 inches were captured per mile of electrofishing, which does rank out in the 59th percentile in the state of Wisconsin, indicating the presence of some more desirable size bluegills. Growth of bluegill in the Cloverleaf Chain was slightly lower than that for the statewide average bluegill growth throughout Wisconsin, reaching 6 inches in 4 – 5 years and 7 inches in 6 years (Figure 16). The average age of bluegill from 5.5 – 6.4 inches and 6.5 – 7.4 inches were 5.3 and 5.8 years respectively, ranking out in the 29th and 34th percentiles statewide, indicating slow to moderate growth of bluegill in the Cloverleaf Chain (Table 5). Bluegill recruitment is consistent in the Cloverleaf Chain of Lakes as bluegills were captured in all half inch size classes between 2.5 – 9.0 inches between the fyke netting and electrofishing surveys (Figure 14; Figure 15).

Black Crappie:

The Cloverleaf Chain also continues to support a very large black crappie population. A total of 662 black crappies were captured in the spring 2017 fyke netting survey for a CPUE of 7.8 black crappies per net night (Table 2; Figure 10). Similar to bluegill, black crappie catch rates in the spring 2017 fyke netting survey were lower than in the previous two fyke netting surveys (Figure 10), yet a catch rate of 7.8 black crappies per net night still ranks out in the 69th percentile when compared to statewide data. This indicates that the Cloverleaf Chain continues to support a high density of black crappies. Thirty-six black crappies were captured in the spring 2017 electrofishing survey for a catch rate of 36.0 per mile of electrofishing (Table 3; Figure 11). Catch rates in the 2017 electrofishing survey were significantly higher than in the previous two electrofishing surveys when catch rates were below five per mile of electrofishing (Figure 11). A catch rate of 36.0 black crappies per mile of electrofishing ranks out in the 87th percentile when compared to data throughout Wisconsin, again indicating a high density of black crappies in the Cloverleaf Chain.

Results from 2017 surveys indicate that the size structure of black crappie in the Cloverleaf Chain is low to moderate. The mean size of black crappies captured in the 2017 spring fyke netting survey and spring electrofishing survey were 5.7 and 7.7 inches, respectively (Table 2; Table 3). Additionally, sizes of black crappie captured in the spring fyke netting survey ranged from 4.2 – 13.2 inches and black crappie captured in the spring electrofishing survey ranged from 5.4 – 9.3 inches (Table 2; Table 3; Figure 14; Figure 15). Black crappie PSD from the 2017 spring fyke netting survey was 9 whereas black crappie PSD from the electrofishing survey was 25 (Figure 12; Figure 13). These two PSD values rank out 5th and 41st percentiles when compared to data throughout the state of Wisconsin, again indicating low to moderate size structure. These values also indicate that black crappies ≥ 8.0 inches are relatively rare in the Cloverleaf Chain of Lakes. Black crappie PSD values from 2017 surveys are lower than what has been observed in previous years surveys, yet black crappie PSD values have been highly variable in the past (Figure 12; Figure 13). This is likely due to highly erratic recruitment in crappies. Results from the 2017 fyke netting survey show a very strong year class of crappies that is between 4.5 – 5.5 inches as over half of the crappies captured were within this size range (Figure 14). Growth of black crappies is also slow to moderate with black crappie mean length at age being below the statewide average for crappie growth for all ages sampled (Figure 17). Additionally, the mean age of black crappies between 7.5 – 8.4 inches and 8.5 – 9.4 inches were 4.1 and 6.7 years, respectively (Table 5). These mean ages at lengths rank out at the 48th and 7th percentile when compared to statewide data, again indicating slow to moderate growth of black crappies in the Cloverleaf Chain.

Pumpkinseed:

Similar to the other two Centrarchid panfish species, the Cloverleaf Chain also supports a large pumpkinseed population. A total of 299 pumpkinseed were captured in the 2017 spring fyke netting survey for an average catch rate of 3.5 per net night (Table 2; Figure 10). Additionally, 17 pumpkinseed were captured in the spring 2017 electrofishing survey for an average catch rate of 17 per mile of electrofishing (Table 3; Figure 11). Catch rates of 3.5 pumpkinseed per net night and 17 pumpkinseed per mile of electrofishing are both considered high catch rates, ranking out in the 71st and 73rd percentiles when compared to statewide data. Furthermore, the catch rates observed in both the 2017 spring fyke netting survey and the 2017 spring electrofishing survey were very similar to catch rates observed in previous years surveys (Figure 10; Figure 11).

Pumpkinseed size structure in the Cloverleaf Chain could be considered moderate. The mean sizes of pumpkinseed captured in the 2017 spring fyke netting survey and electrofishing survey were 5.2 and 6.1 inches, respectively (Table 2; Table 3). Additionally, pumpkinseeds captured in the 2017 fyke netting survey range in size from 3.2 – 7.4 inches, whereas pumpkinseed captured in the 2017 electrofishing survey ranged in size from 4.8 – 7.6 inches (Table 2; Table 3; Figure 14; Figure 15). Pumpkinseed PSD values from fish captured in the 2017 fyke netting survey were low at a PSD of 21, ranking out in the 25th percentile when compared to statewide data (Figure 12). Furthermore, size structure of pumpkinseed captured in spring fyke netting surveys has shown a downward trend through time, indicating a higher proportion of smaller individuals in the population through time (Figure 12). However, pumpkinseed captured in the spring 2017 electrofishing survey had a PSD of 53, ranking out in the 79th percentile when compared to data throughout the state of Wisconsin (Figure 13). Trends in PSD values from pumpkinseed captured in spring largemouth bass/panfish electrofishing surveys have been increasing through time (Figure 13). Three pumpkinseed ≥ 7.0 inches were captured per mile of electrofishing in the spring 2017 electrofishing survey, which ranks out in the 84th percentile statewide. Pumpkinseed recruitment appears to be consistent through time given the even distribution of pumpkinseed captured between 3.0 – 8.0 inches in spring 2017 fyke netting and electrofishing surveys (Figure 14; Figure 15).

Yellow Perch:

Yellow perch are difficult to capture with either fyke nets or electrofishing, making it difficult to assess the current status of the yellow perch population in the Cloverleaf Chain of Lakes. Only 33 yellow perch were captured in the spring 2017 fyke netting survey for a CPUE of 0.4 yellow perch per net night (Table 2; Figure 10). A CPUE of 0.4 yellow perch per net night ranks out in the 25th percentile when compared to statewide data, indicating a low yellow perch density. Only four yellow perch were captured during the spring 2017 electrofishing survey for a mean CPUE of four yellow perch per mile of electrofishing. Four yellow perch per mile of electrofishing is also considered a low catch rate, ranking out in the 30th percentile when compared to statewide data. Catch rates of yellow perch have been low in the previous couple of spring fyke netting and electrofishing surveys, with catch rates below one yellow perch per net night in all fyke netting surveys between 2008 and 2017 and catch rates being below 10.5 yellow perch per mile of electrofishing in the 2013 and 2017 surveys (Figure 10; Figure 11). Yellow perch CPUE was fairly high in the spring 2008 electrofishing survey when 63 yellow perch per mile of electrofishing were captured (Figure 11). However, catches seemed to be dominated by two small year classes as the mean size of yellow perch captured in spring 2008 was 4.4 inches with only one yellow perch ≥ 6.5 inches captured.

The yellow perch population in the Cloverleaf Chain has historically been dominated by smaller individuals and that trend continued through 2017 surveys. The mean size of the yellow perch captured in the 2017 spring fyke netting and electrofishing surveys was 6.3 and 5.8 inches respectively (Table 2; Table 3). Yellow perch captured in the spring 2017 fyke netting survey ranged in size from 4.6 – 8.8 inches, whereas yellow perch captured in the spring 2017 electrofishing survey ranged in size from 4.3 – 8.4 inches (Table 2; Table 3; Figure 14; Figure 15). Furthermore, yellow perch PSD values in the spring 2017 fyke netting survey was only 15 and yellow perch PSD values from the spring 2017 electrofishing was 50, although only four yellow perch were captured in the spring 2017 electrofishing survey, resulting in a low sample size (Figure 12; Figure 13). Yellow perch PSD values have been ≤ 20 in all historical spring fyke netting surveys and was < 10 in the 2008 and 2013 spring electrofishing survey, indicating that the yellow perch population in the Cloverleaf Chain has historically been dominated by smaller individuals. However, as noted earlier, it is very difficult to sample yellow perch with fyke nets or electrofishing gear, making it difficult to assess the current status of the yellow perch fishery using these two gears.

Discussion:

The Cloverleaf Chain of Lakes has historically and continues to provide diverse fishing opportunities for both gamefish and panfish species. Four popular gamefish species including largemouth bass, northern pike, muskellunge, and walleye along with four popular panfish species including bluegill, pumpkinseed, black crappie, and yellow perch were all captured in spring 2017 surveys. Most of these species were found in moderate – high densities with harvestable size individuals of most species captured, indicating plenty of fishing opportunities exist within the Cloverleaf Chain of Lakes.

Historically, the Cloverleaf Chain of Lakes has supported a self-sustaining northern pike fishery since the initial stockings of northern pike in the 1940s and 1950s. Adult northern pike stocked in the late 1950s were likely the stockings that started the northern pike population. Between 1960 and 2013, only one stocking of northern pike took place in 1989, meaning natural reproduction was sustaining a healthy northern pike population in the Cloverleaf Chain. However, results from recent fisheries surveys have shown significant declines in northern pike numbers, likely due to declines in natural reproduction. As a result, large fingerling northern pike were stocked in 2014 and 2017. Furthermore, northern pike size structure and condition continue to remain poor. Only a small percentage of northern pike captured were > 21.0 inches and northern pike condition was poor. Early spring, right before spawning, is when northern pike conditions should be the highest.

Limited high quality natural and native habitat could be contributing to recent declines in northern pike reproduction and recruitment and poor condition. Northern pike prefer to spawn in shallow marshy areas with emergent vegetation such as grasses, sedges, and rushes and often associate with native submersed aquatic vegetation throughout most of their lives (Becker 1983). Efforts should be made to protect and restore natural habitats including native submersed and emergent aquatic vegetation, especially in areas that contain essential spawning habitat such as bulrushes. Furthermore, efforts should be made to protect the designated sensitive areas (Olson 2003) as well as expand fish sticks and coarse woody habitat along with shoreland restoration (NES Ecological Services 2011). Additional habitat will benefit not only northern pike but all species of fish in the Cloverleaf Chain of Lakes.

Muskellunge stocking has been highly successful at establishing a high-quality musky fishery within the Cloverleaf Chain of Lakes. Despite being a small waterbody and considered a Class B musky fishery (i.e., an intermediate class of waters where angler success and catch rates may be lower than in prime Class A waters; Simonson 2012), the Cloverleaf Chain of Lakes has consistently produced moderate densities of muskies and also has the potential to grow really large muskies. Catch rates of muskies in the spring fyke netting survey have decreased slightly over the past 10 years, but still remain moderate at 0.5 muskellunge per net night in 2017. Decreases in musky stocking rate and frequency since 2006 have likely resulted in the slight decreases in catch rates over the past 10 years. In total, the average size of muskies captured in the spring 2017 fyke net survey was 39.7 inches with 13 muskies over 40 inches being captured, and two over 45 inches being captured. These numbers could rival the growth potential and size structure of some Class A musky fisheries. Another spring fyke netting survey is planned for spring 2018 to serve as a recapture period to get a musky population estimate (i.e., an estimate of the total number of muskies) for the Cloverleaf Chain of Lakes. No evidence of muskellunge natural reproduction has been observed in the Cloverleaf Chain, making stocking essential to maintain a musky fishery in the future.

The Cloverleaf Chain of Lakes has a long history of walleye stockings to maintain a walleye fishery. Regular walleye stockings began in the Cloverleaf Chain in the 1960s, yet recording the sizes of walleyes stocked didn't begin until the early 1980s. Walleye stockings since the early 1980s can be grouped into three different periods that resulted in seemingly variable success rates. The first period extends throughout the 1980s, when larger walleyes were stocked. Between 1983 and 1989, a total of 59,807 walleyes were stocked with an average size of 3.8 inches. The average size of walleyes in some individual stockings were 7.0 inches in 1987 and 10.0 inches in 1989. Peak densities of walleyes also occurred in the 1980s and early 1990s with catch rates of walleyes at 2.7, 2.1, and 0.8 walleyes per net night in spring fyke netting surveys in 1985, 1988, and 1994, respectively. Furthermore, while the walleye population was dominated by larger individuals during these surveys, PSD values were in the 80s and 90s indicating some smaller individuals were captured in each survey, with multiple year classes and size classes present in the fishery.

Starting in the early 1990s smaller walleyes were stocked in the Cloverleaf Chain. Between 1992 and 2008, a total of 98,657 walleyes were stocked into the Cloverleaf Chain with a mean size of only 2.2 inches, 1.5 inches smaller than the average size walleye stocked in the 1980s. Furthermore, the average size of stocked walleyes in five of the nine stocking events that took place during this time frame was ≤ 1.7 inches. Following the switch to stocking smaller walleyes, catch rates declined and very few small walleyes were captured indicating poor survival of stocked walleyes and a population dominated by large, old walleyes. Catch rates declined to 0.6, 0.3, and 0.1 walleyes per net night in spring fyke netting surveys in 2000, 2008, and 2013, respectively. Furthermore, only one walleye < 20 inches was captured in the 2008 fyke netting survey and the smallest walleye captured in the spring 2013 fyke netting survey was > 23 inches.

Between 2013 and 2015, 11,622 walleyes averaging 7.1 inches were stocked into the Cloverleaf Chain of Lakes. Although these walleyes are still relatively young (i.e., ≤ 4 years old), results from the 2017 surveys show that individuals from both these year classes are surviving. Eleven walleyes between 10.6 – 13.1 inches (likely two year olds from the 2015 year class) and three walleyes between 15.9 – 16.3 inches (likely four year olds from the 2013 year class) were captured in the spring 2017 fyke netting survey. Additionally, 33 walleyes between 10.5 – 13.4 inches (likely two year olds from the 2015 year class) and two walleyes between 15.2 – 16.7 inches (likely four year olds from the 2013 year class) were captured in the spring 2017 electrofishing survey. High catch rates of young walleyes shows promise of two strong year classes that could provide a nice fishery in the future.

The large size of the walleyes stocked in 2013 and 2015 likely contributed to much higher survival when compared to the smaller walleyes stocked in previous years. Research has shown that the size of stocked walleyes influenced survival rates and year class strength in 24 Wisconsin lakes with large fingerling stockings resulting in higher survival to age – 1 and more consistent year classes when compared to small fingerling stockings (Kampa and Hatzenbeler 2009). Furthermore, catch per unit effort of age-1 walleyes was four times greater in Wisconsin lakes stocked with large fingerling walleyes compared to lakes stocked with small fingerling walleyes, indicating higher survival and stronger year classes from large fingerling walleyes (Kampa and Hatzenbeler 2009). Hopefully the walleyes stocked in 2017 as part of the Wisconsin Walleye Initiative will provide a third year class of walleyes to the fishery in the Cloverleaf Chain. Given that stocking small fingerlings here had little success, only large fingerling walleyes should be stocked in the future.

Given that results have shown that the stockings of large fingerlings in 2013 and 2015 were successful at establishing year classes of walleyes in the Cloverleaf Chain, one option to explore to enhance the quality of the walleye fishery in the future would be to change the regulation to an 18 inch minimum and a daily bag limit of three. Several counties in southern Wisconsin have recently changed the county wide regulation for walleyes from the statewide default (15 inch minimum and daily bag limit of 5) to the 18 inch minimum and daily bag limit of 3. A comparison of survey results from southern Wisconsin lakes with the statewide default regulation (15 inch minimum length limit and daily bag limit of 5) and the proposed special regulation (18 inch minimum and daily bag limit of 3) showed that lakes with the proposed special regulation averaged 2.89 adult walleye per acre compared to 0.89 for the lakes with the statewide default regulation. Additionally, spring electrofishing catch rates average 26.7 walleyes per mile of electrofishing in lakes with the proposed special regulation compared to 9.6 walleyes per mile of electrofishing in lakes with the statewide default regulation. These southern Wisconsin fisheries typically have lower density walleye fisheries with moderate – fast growth that are sustained primarily with stocking. The walleye fishery in the Cloverleaf Chain shares these same characteristics. Changing the walleye regulation for the Cloverleaf Chain of Lakes has the potential to increase numbers of walleyes and the quality of the walleye fishery as seen in southern Wisconsin lakes.

Largemouth bass are maintaining a high density, self-sustaining fishery in the Cloverleaf Chain of Lakes. Increases in largemouth bass densities over the last decade and resulting increases in predation on small Centrarchids (i.e., sunfish and crappies) could explain the decreases in catch rates of these Centrarchids. The biggest concern regarding the largemouth bass population is that very few large largemouth bass were captured. Previous surveys have shown that largemouth bass growth rates are slow to moderate in the Cloverleaf Chain and these trends are likely continuing given the observed size structure. Limited high quality habitat is likely a key factor driving the slower growth rates. In a response to a lack of high quality habitat, six sensitive areas were designated for preservation in 2003 (Olson 2003). These sensitive areas should be protected and enhanced to maintain their high quality. The fish sticks added around Gibson Island in 2016 will also provide high quality largemouth bass habitat. Areas for additional fish sticks should be explored. Last, local lakeshore owners should consider restoring their shoreland following protocols described NES Ecological Services (2011). Preserving and enhancing littoral habitat will not only help the largemouth bass population, but it will help all fish species within the Cloverleaf Chain.

One ongoing concern regarding the panfish population in the Cloverleaf Chain of Lakes has been the lack of many large individuals in the population, especially with bluegill. Although bluegill PSD values in 2017 were found at moderate levels when compared to statewide data, 10% or less of the bluegill captured in either the 2017 fyke netting or electrofishing surveys were ≥ 7.0 inches and very few bluegill ≥ 8.0 inches were captured with either gear. Several factors could be contributing to the observed trends in size structure of panfish in the Cloverleaf Chain. The first is significant angling pressure removing the largest individuals from the population. Although no creel surveys have been conducted on the Cloverleaf Chain in recent years, it is known that the Cloverleaf Chain does receive good amounts of fishing pressure year-round. Research has shown that significant amounts of angling pressure can reduce the size structure of bluegill populations by selectively removing the largest bluegills (Goedde and Coble 1981; Coble 1988; Beard and Essington 2000). A special regulation aimed at protecting some of the largest bluegill and pumpkinseed in the population from harvest was put in place in 2016, but it is likely still to early for that regulation to have had any significant effect.

A second factor potentially affecting bluegill size structure that can be directly linked to anglers selectively removing the largest males in a population is the social structure of bluegills during spawning. Male bluegills build and guard nests in spawning colonies and will compete for the best spawning locations within that colony, often in the center where chances of nest predation are lowest (Gross and MacMillan 1981). When large male bluegills are present in a population, smaller male bluegills will not be able to compete for the prime nesting locations and will delay maturation until they are large enough to compete for prime nests (Jennings et al. 1997; Aday et al. 2006; Hoxmeier et al. 2009). When large males are absent, smaller male bluegills can easily secure the best nest sites, resulting in males maturing at younger ages and smaller sizes (Jennings et al. 1997; Aday et al. 2003; Aday et al. 2006; Hoxmeier 2009). Age and size at maturation is very important to bluegill growth because when a bluegill matures, it devotes significant excess energy towards reproduction rather than growth, and growth slows considerably. Few large males in a population can result in lakes with bluegills that mature at younger ages and smaller sizes and a population dominated by smaller individuals (Drake et al. 1997). Survey results have shown that few large bluegills are present in the Cloverleaf Chain potentially allowing for successful maturation at reproduction at smaller size. Furthermore, results from 2017 surveys showed that bluegill growth rates were just below the statewide average and that bluegill growth was slow-moderate. Early maturation could be contributing to the observed slow-moderate growth. Again, a special panfish regulation allowing harvest of only five bluegill and pumpkinseed larger than seven inches was put in place in spring 2016 to try to protect some of the largest males from harvest. This regulation will hopefully increase the quality of the bluegill fishery by protecting some of the largest bluegills and pumpkinseed from harvest and may also help prevent early maturation if that is going on in the Cloverleaf Chain of Lakes.

A third factor that could be affecting size structure is density dependent competition limiting growth rates. The Cloverleaf Chain has a history of supporting high densities of panfish. Black crappie and bluegill CPUE in spring 2017 fyke netting surveys averaged 7.8 and 15.3 black crappie and bluegill per net night, respectively. These CPUEs ranked out in the 69th and 60th percentiles statewide, indicating moderate to moderate – high densities. However, catch rates observed in 2017 were quite a bit lower than what was observed in surveys in 2008 and 2013 when black crappie and bluegill catch rates were as high as 35.6 black crappies and 43.0 bluegill per net night. High catch rates have also been observed in historical electrofishing surveys. When densities of panfish get high, there are very few resources available for each individual and competition for those limited resources is very high. As a result, growth usually slows. Slow growth stemming from density dependent competition has been shown throughout bluegill populations in the upper Midwest including Wisconsin, Minnesota, and Michigan (Wiener and Hanneman 1982; Osenberg et al. 1988; Tomcko and Pierce 2005). As mentioned earlier, results from 2017 surveys showed that bluegill were growing at slow-moderate rates for Wisconsin, below the statewide average. Even though panfish densities have declined in recent years, a lot of the adults that are currently in the population would have done most of their growing 4 – 6 years ago when densities were higher, so they may have experienced more density dependent competition during their prime growing years. Increases in predator numbers such as largemouth bass and small walleyes may have contributed to recent declines in panfish densities. Continued increases in predator densities could help keep panfish at lower densities and hopefully improve growth rates.

While black crappies tend to pull off a year class in most years in the Cloverleaf Chain (individuals from the 2009, 2012, 2013, 2014, and 2015 year classes were captured), year class strength appears to be highly variable and some year classes absent. For example, over half of the black crappies captured in the 2017 spring fyke netting survey were between 4.5 – 5.5 inches, and likely all were from the 2015 year class. The 2015 year class appears to be much stronger than the 2014 or 2013 year classes as significantly fewer age – 3 and age – 4 crappies were captured and given the growth rates of black crappies in the Cloverleaf Chain (i.e., mean length of 6.4 inches at age – 3 and 7.6 inches at age – 4), these two year classes likely have not experienced significant exploitation yet. Given that crappie recruitment has been shown to be variable and even highly erratic in lakes and impoundments throughout the United States (e.g., Hooe 1991; Guy and Willis 1995; Allen and Miranda 1998), it is not surprising that results from fisheries surveys of the Cloverleaf Chain show that crappie recruitment within the Chain can also be variable and erratic.

One fishery that may be overlooked in the Cloverleaf Chain of Lakes is the rock bass fishery. Results from the 2017 netting and electrofishing surveys show a healthy rock bass population within the Cloverleaf Chain as 100 rock bass were captured in the spring fyke netting survey and 56 were captured in the spring electrofishing survey for catch rates of 1.2 per net night and 56 per mile of electrofishing. The average size of rock bass captured in the spring fyke netting survey was 5.75 inches with a range from 3.8 – 9.2 inches. The average size of rock bass captured in the spring electrofishing survey was 6.5 inches with a range from 2.8 – 9.8 inches. Furthermore, plenty of harvestable size rock bass were captured in the Cloverleaf Chain as rock bass ≥ 7.0 inches comprised 23% of the fyke netting catch and 39% of the electrofishing catch. Current fishing regulations allow for unlimited harvest of rock bass with no size limit.

Summary and Management Recommendations:

1.) Preserve and expand natural habitat. Efforts should be made to promote a diverse mix of native submersed and emergent aquatic plants throughout the Cloverleaf Chain of Lakes. Furthermore, the designated sensitive areas should be protected and enhanced. Littoral coarse woody habitat (i.e. fish sticks) should be added where feasible to expand available woody habitat. Shorelands could be restored to more natural conditions following protocols described by NES Ecological Services (2011). Control overabundant invasive plants as necessary.

2.) Continue to stock muskellunge to maintain a low to moderate density, high quality muskellunge fishery. Despite being classified as a Class B musky fishery, the Cloverleaf Chain supports a moderate density of muskellunge and has the potential to grow large muskies. Thirteen muskies over 40 inches were captured in the spring 2017 fyke netting survey including a 47.4 inch musky. Large fingerling muskellunge should be stocked at a rate of 1 per acre (i.e., 316 muskellunge) every 2 – 3 years.

3.) Continue to stock walleyes to maintain a put – grow – take walleye fishery. Large fingerling walleye should be stocked as historical survey results have shown limited success of stocking small fingerling walleyes. Results from 2017 surveys show evidence of good survival of the 2013 and 2015 year classes of large fingerlings and most walleyes captured in 2017 were < 17.0 inches long, likely from the 2013 and 2015 year classes. Stocking should continue at a rate of 10 per acre (i.e., 3,160 walleyes) every 2 years. With continued stocking of large fingerlings, hopefully catch rates in spring fyke netting surveys will increase to 2 – 3 adult walleyes per net night and population estimates will result in 1 – 2 adult walleyes per acre in the Cloverleaf Chain of Lakes. A regulation aimed at increasing the minimum size limit and decreasing the bag limit may also enhance the walleye fishery in the Cloverleaf Chain. The success of stocking large fingerling walleyes will again be evaluated during the next comprehensive survey in 2021.

4.) Continue to work to improve panfish size structure. Bluegill PSD values are moderate to high, but large bluegills (i.e., ≥ 7 – 8 inches) remain rare. Results of surveys between 2008 and 2017 have indicated that numbers of panfish have been decreasing in the Cloverleaf Chain of Lakes. Reductions in density should result in increased growth rates through time as more resources are available to individuals. The special panfish regulation put in place in 2016 will hopefully protect some of the largest bluegill and pumpkinseed from harvest and promote delayed maturation and faster growth among smaller juvenile bluegill. The special panfish regulation will be evaluated during the next comprehensive survey in 2021. Hopefully the combination of lower density and the special regulation will result in increases in bluegill size structure so that bluegill have an RSD – 7 of 20 – 30 and an RSD – 8 of 5 – 10 by the next comprehensive survey in 2021.

5.) Continue to monitor the northern pike population. Two stockings of large fingerling northern pike took place in 2014 and 2017 following declines in the numbers of northern pike. Protecting and enhancing areas of native emergent and submergent vegetation will provide the best opportunities for northern pike to successfully spawn in the Cloverleaf Chain and will also provide optimal habitat for juvenile and adult northern pike.

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TABLE 1. Species stocked, stocking year, age at stocking, mean length at stocking, and number of each species stocked into the Cloverleaf Chain of Lakes, Shawano County, Wisconsin between 1939 and 2017.

Species	Year	Age	Mean Length (Inches)	Number Stocked
MUSKELLUNGE	2017	LARGE FINGERLING	12.0	316
NORTHERN PIKE	2017	LARGE FINGERLING	8.5	900
WALLEYE	2017	LARGE FINGERLING	3.3	3,172
WALLEYE	2015	LARGE FINGERLING	7.0	2,100
WALLEYE	2015	LARGE FINGERLING	7.8	3,184
NORTHERN PIKE	2014	LARGE FINGERLING	9.5	796
MUSKELLUNGE	2014	LARGE FINGERLING	9.8	316
WALLEYE	2013	LARGE FINGERLING	6.8	6,338
MUSKELLUNGE	2010	LARGE FINGERLING	13.2	193
WALLEYE	2008	SMALL FINGERLING	1.5	11,290
MUSKELLUNGE	2008	LARGE FINGERLING	10.3	640
WALLEYE	2006	SMALL FINGERLING	1.4	15,985
MUSKELLUNGE	2006	LARGE FINGERLING	13.0	200
MUSKELLUNGE	2006	LARGE FINGERLING	10.8	140
WALLEYE	2004	SMALL FINGERLING	1.4	15,990
MUSKELLUNGE	2004	LARGE FINGERLING	10.5	638
WALLEYE	2002	LARGE FINGERLING	6.0	1,150
MUSKELLUNGE	2002	LARGE FINGERLING	10.1	640
WALLEYE	2000	SMALL FINGERLING	1.7	11,000
MUSKELLUNGE	2000	LARGE FINGERLING	11.4	450
WALLEYE	1998	SMALL FINGERLING	1.7	8,850
YELLOW PERCH	1997	FINGERLING	5.0	3,000
WALLEYE	1997	LARGE FINGERLING	2.7	11,000
WALLEYE	1996	FINGERLING	1.6	14,954
MUSKELLUNGE	1995	LARGE FINGERLING	14.0	200
WALLEYE	1994	FINGERLING	3.6	16,303
MUSKELLUNGE	1992	FINGERLING	11.0	646
WALLEYE	1992	FINGERLING	3.0	8,120
MUSKELLUNGE	1991	FINGERLING	10.9	640
MUSKELLUNGE	1989	FINGERLING	11.0	640
WALLEYE	1989	YEARLING	10.0	4,500
NORTHERN PIKE	1989	LARGE FINGERLING	11.0	325
YELLOW PERCH	1989	LARGE FINGERLING	5.5	300
FATHEAD MINNOWS	1989	-	-	3 GALLONS
LARGEMOUTH BASS	1988	FINGERLING	4.0	1,364
WALLEYE	1988	FINGERLING	4.0	400
MUSKELLUNGE	1987	FINGERLING	9.0	640
WALLEYE	1987	FINGERLING	7.0	11,050

TABLE 1 CONTINUED. Species stocked, stocking year, age at stocking, mean length at stocking, and number of each species stocked into the Cloverleaf Chain of Lakes, Shawano County, Wisconsin between 1939 and 2017.

Species	Year	Age	Mean Length (Inches)	Number Stocked
WALLEYE	1986	FINGERLING	3.0	1,297
LARGEMOUTH BASS	1986	FINGERLING	3.0	943
MUSKELLUNGE	1985	FINGERLING	12.0	1,680
WALLEYE	1985	FINGERLING	2.0	28,200
WALLEYE	1984	FINGERLING	2.8	1,500
MUSKELLUNGE	1983	FINGERLING	10.0	455
WALLEYE	1983	FINGERLING	5.0	14,535
WALLEYE	1983	FINGERLING	3.0	2,500
MUSKELLUNGE	1982	FINGERLING	10.0	310
WALLEYE	1982	FRY	-	10,000
MUSKELLUNGE	1980	FINGERLING	8.0	630
MUSKELLUNGE	1979	FINGERLING	8.0	630
MUSKELLUNGE	1978	FINGERLING	8.0	630
MUSKELLUNGE	1977	FINGERLING	8.0	630
MUSKELLUNGE	1976	FINGERLING	13.0	625
MUSKELLUNGE	1974	FINGERLING	-	1,300
WALLEYE	1974	FINGERLING	-	10,000
MUSKELLUNGE	1973	FINGERLING	-	1,300
WALLEYE	1973	FINGERLING	-	10,484
MUSKELLUNGE	1970	FINGERLING	-	700
WALLEYE	1970	FINGERLING	-	19,762
WALLEYE	1969	FINGERLING	-	36,270
MUSKELLUNGE	1966	FINGERLING	-	800
MUSKELLUNGE	1965	FINGERLING	-	5,580
MUSKELLUNGE	1964	FINGERLING	-	6,200
MUSKELLUNGE	1963	FINGERLING	-	150
MUSKELLUNGE	1962	YEARLING	-	625
WALLEYE	1961	FINGERLING	-	63,000
NORTHERN PIKE	1959	ADULT	-	270
NORTHERN PIKE	1956	ADULT	-	3,255
NORTHERN PIKE	1955	UNKNOWN	-	3,802
BROWN TROUT	1951	LEGAL	-	2,000
NORTHERN PIKE	1950	FRY	-	70,000
NORTHERN PIKE	1946	FRY	-	50,000
LARGEMOUTH BASS	1945	FINGERLING	-	200
LARGEMOUTH BASS	1943	FINGERLING	-	650
NORTHERN PIKE	1942	FRY	-	41,096

TABLE 1 CONTINUED. Species stocked, stocking year, age at stocking, mean length at stocking, and number of each species stocked into the Cloverleaf Chain of Lakes, Shawano County, Wisconsin between 1939 and 2017.

Species	Year	Age	Mean Length (Inches)	Number Stocked
BULLHEAD SPP	1941	ADULT	-	500
BULLHEAD SPP	1941	FINGERLING	-	1,500
BLACK CRAPPIE	1941	ADULT	-	903
YELLOW PERCH	1941	ADULT	-	1,100
YELLOW PERCH	1941	FINGERLING	-	7,500
SUNFISH SPP	1941	ADULT	-	2,000
WALLEYE	1941	FRY	-	500,000
BLUEGILL	1940	ADULT	-	50
BLACK CRAPPIE	1940	ADULT	-	1,000
ROCK BASS	1940	ADULT	-	50
WALLEYE	1940	FRY	-	500,000
BLUEGILL	1939	ADULT	-	5,500
BULLHEAD SPP	1939	ADULT	-	400
BULLHEAD SPP	1939	FINGERLING	-	84,400
BLACK CRAPPIE	1939	ADULT	-	800
LARGEMOUTH BASS	1939	FINGERLING	-	4,000
YELLOW PERCH	1939	ADULT	-	800
YELLOW PERCH	1939	FINGERLING	-	16,600
SUNFISH SPP	1939	ADULT	-	500
SUNFISH SPP	1939	FINGERLING	-	3,300

TABLE 2. Number of each species captured along with mean lengths and size ranges (in inches) of all gamefish and panfish species captured in spring fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, spring 2017.

Species	Number Captured	Mean Length (Range)
BLACK BULLHEAD	3	-
BLACK CRAPPIE	662	5.7 (4.2 - 13.2)
BLUEGILL	1,300	5.8 (3.6 - 8.6)
BOWFIN	12	-
BROWN BULLHEAD	1	-
GREEN SUNFISH	1	-
GREEN SUNFISH X PUMPKINSEED	1	-
LAKE CHUBSUCKER	4	-
LARGEMOUTH BASS	20	9.2 (5.8 - 16.5)
MUSKELLUNGE	42	39.7 (33.3 - 47.4)
NORTHERN PIKE	109	16.6 (9.5 - 31.0)
PUMPKINSEED	299	5.2 (3.2 - 7.4)
ROCK BASS	100	-
WALLEYE	17	13.8 (10.6 - 25.8)
WHITE SUCKER	1	-
YELLOW BULLHEAD	18	-
YELLOW PERCH	33	6.3 (4.6 - 8.8)

TABLE 3. Number of each species captured along with mean lengths and size ranges (in inches) of all gamefish and panfish species captured in spring electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, spring 2017.

Species	Number Captured	Mean Length (Range)
BLACK CRAPPIE	36	7.7 (5.4 - 9.3)
BLUEGILL	107	5.9 (2.5 - 7.6)
BLUNTNOSE MINNOW	1	-
BOWFIN	1	-
BROWN BULLHEAD	2	-
COMMON CARP	2	-
LARGEMOUTH BASS	174	10.5 (4.1 - 16.4)
NORTHERN PIKE	19	15.3 (9.7 - 21.2)
PUMPKINSEED	17	6.1 (4.8 - 7.6)
ROCK BASS	56	6.5 (2.8 - 9.8)
WALLEYE	35	12.0 (10.5 - 16.7)
YELLOW BULLHEAD	9	-
YELLOW PERCH	4	5.8 (4.3 - 8.4)

TABLE 4. Summary statistics for northern pike marking (i.e., partial top caudal/tail fin clip) and recaptures from the 2017 spring fyke netting survey that was used to estimate northern pike abundance in the Cloverleaf Chain of Lakes using a Schanbel mark-recapture model. Parameters included are the number of northern pike marked during netting, number of sampling events (i.e., days the nets were checked), number of northern pike that were recaptured, the Schnabel population estimated including the 95% confidence intervals, and the number of northern pike per acre.

Species	Number Marked (Netting)	Number Sampling Events	Number Recaptures	Schnabel Population Estimate (95% Confidence Intervals)	Number per Acre
NORTHERN PIKE	85	11	13	268 (170 - 629)	0.85

TABLE 5. Summary statistics for bluegill and black crappie growth rates from fish collected in the 2017 spring fyke netting survey of the Cloverleaf Chain of Lakes, Shawano County, WI. Statistics included are the total number of bluegill and black crappie of a given length collected, length bin of interest, mean age of the bluegill and black crappie in the length bin of interest, age range of bluegill and black crappie in the length bin of interest, percentile rank when compared to statewide bluegill and black crappie growth rates, and the growth rating when compared to statewide bluegill and black crappie growth rates.

Species	Number Sampled	Length Bin (inches)	Mean Age (years)	Age Range (years)	Percentile Rank	Growth Rating
BLUEGILL	34	5.5 - 6.4	5.3	4 - 6	29th	Slow
BLUEGILL	30	6.5 - 7.4	5.8	4 - 7	34th	Slow - Moderate
BLACK CRAPPIE	8	7.5 - 8.4	4.1	4 - 5	48th	Moderate
BLACK CRAPPIE	3	8.5 - 9.4	6.7	4 - 8	7th	Slow

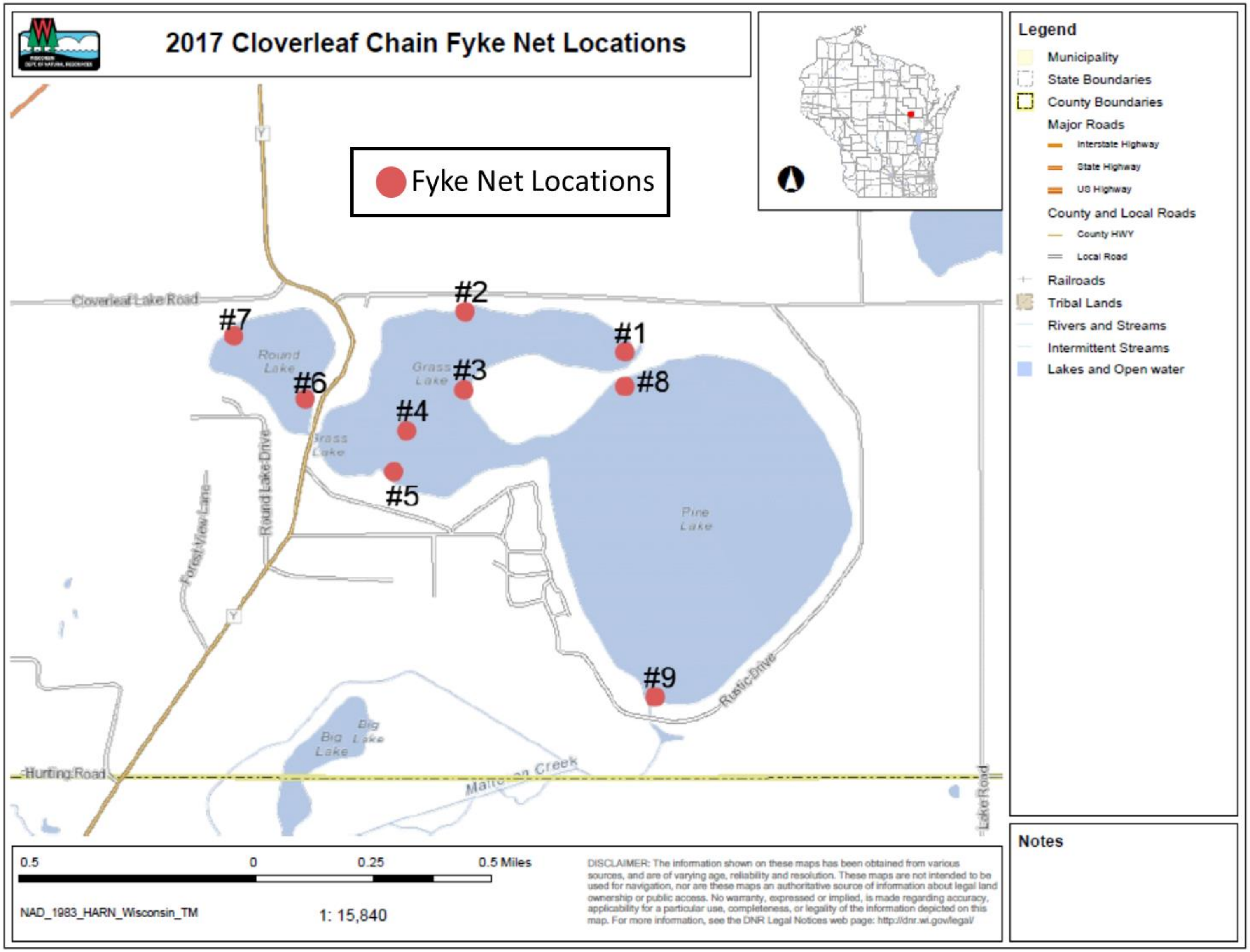

FIGURE 1. Fyke net locations for the spring fyke netting survey I and spring fyke netting survey II conducted by the WDNR on the Cloverleaf Chain of Lakes between 4/3/2017 and 4/14/2017.

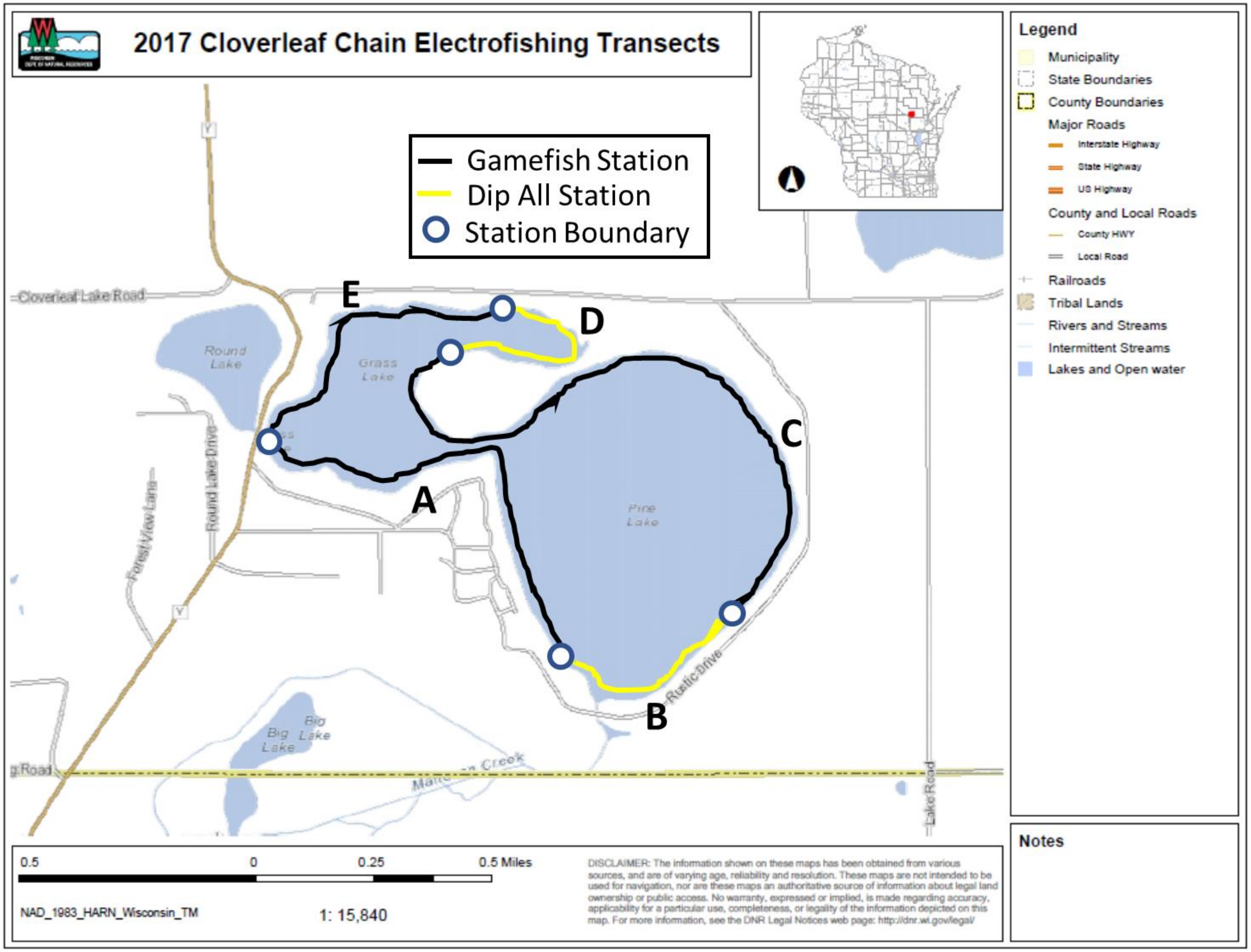

FIGURE 2. Electrofishing station locations for the spring largemouth bass and panfish electrofishing sample collected by the WDNR on the Cloverleaf Chain of Lakes on 5/18/2017. Black lines represent gamefish only stations. Yellow lines represent dip all stations. White circles with dark blue borders represent station boundaries. Letters denote specific stations.

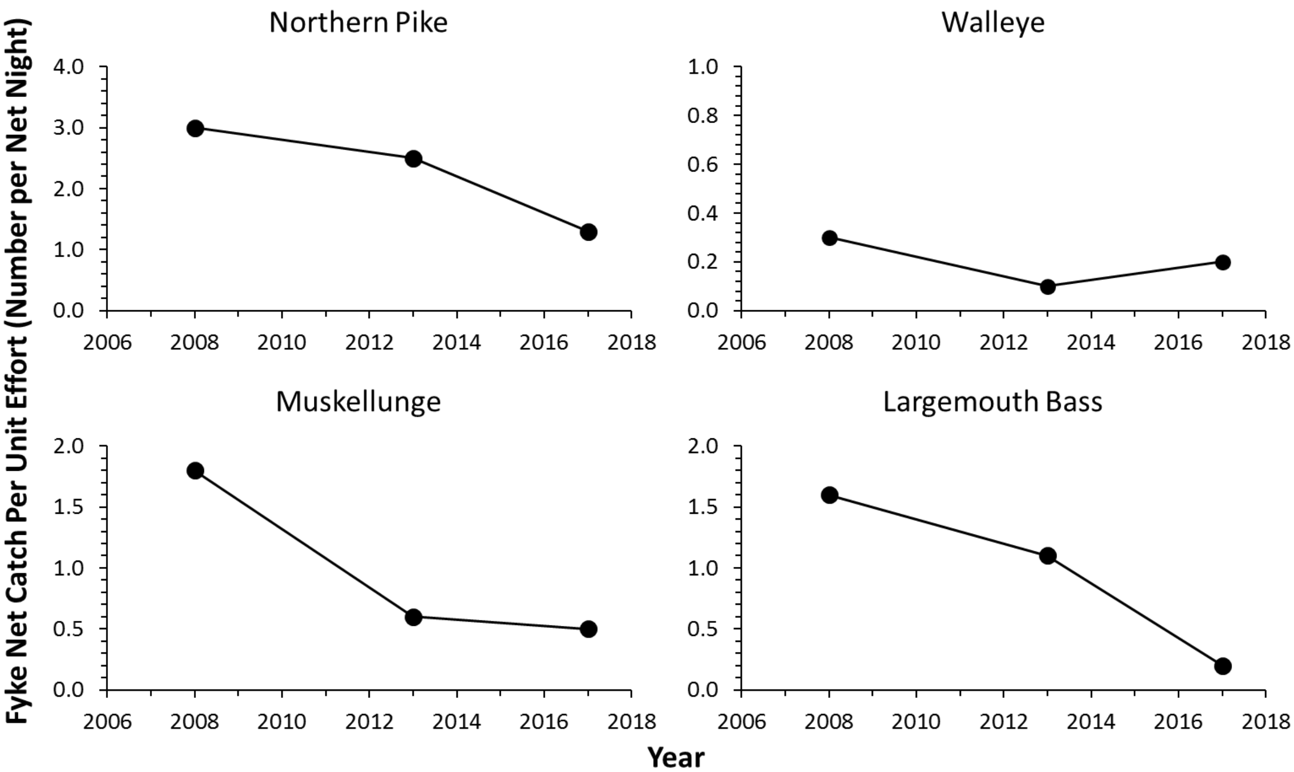

FIGURE 3. Catch per unit effort (CPUE) for northern pike, walleye, muskellunge, and largemouth bass captured in spring fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 2008 – 2017.

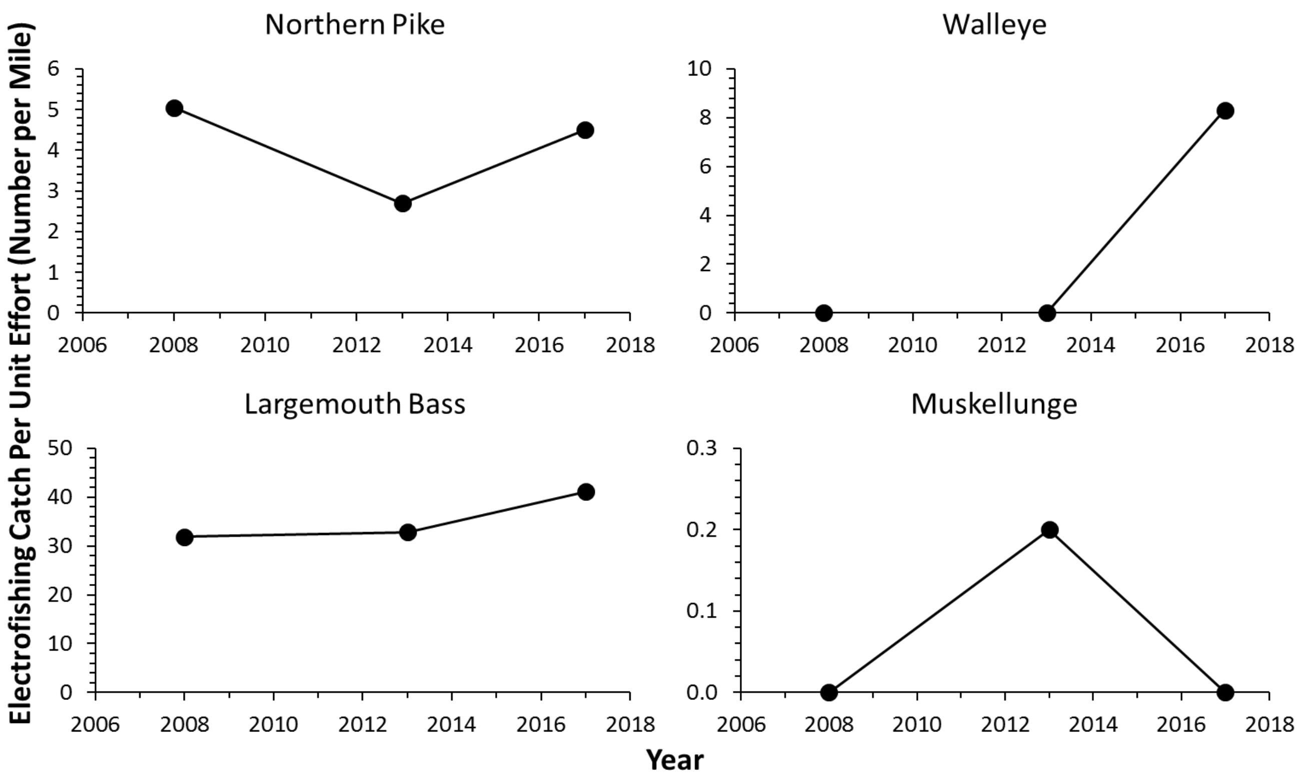

FIGURE 4. Catch per unit effort (CPUE) for northern pike, walleye, muskellunge, and largemouth bass captured in spring largemouth bass/panfish electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 2008 – 2017.

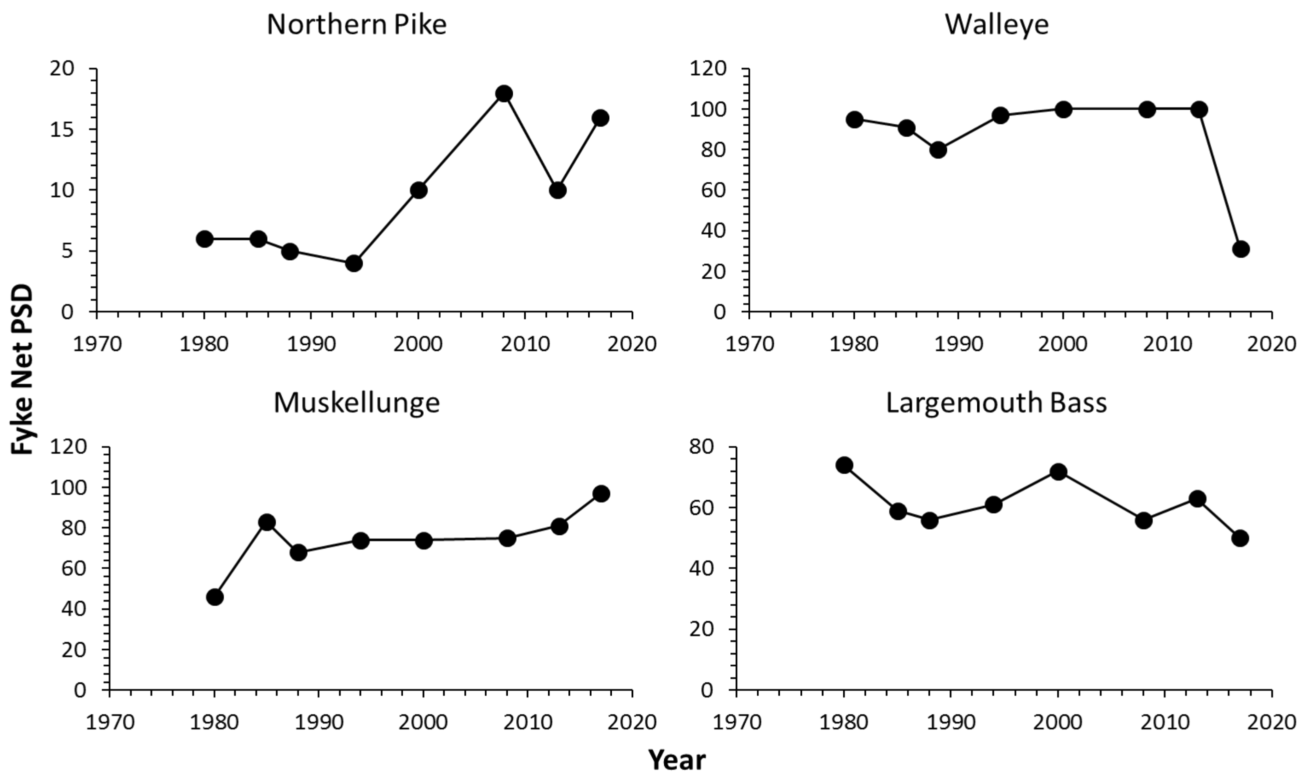

FIGURE 5. Proportional stock density (PSD) values for northern pike, walleye, muskellunge, and largemouth bass captured in spring fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 1980 – 2017.

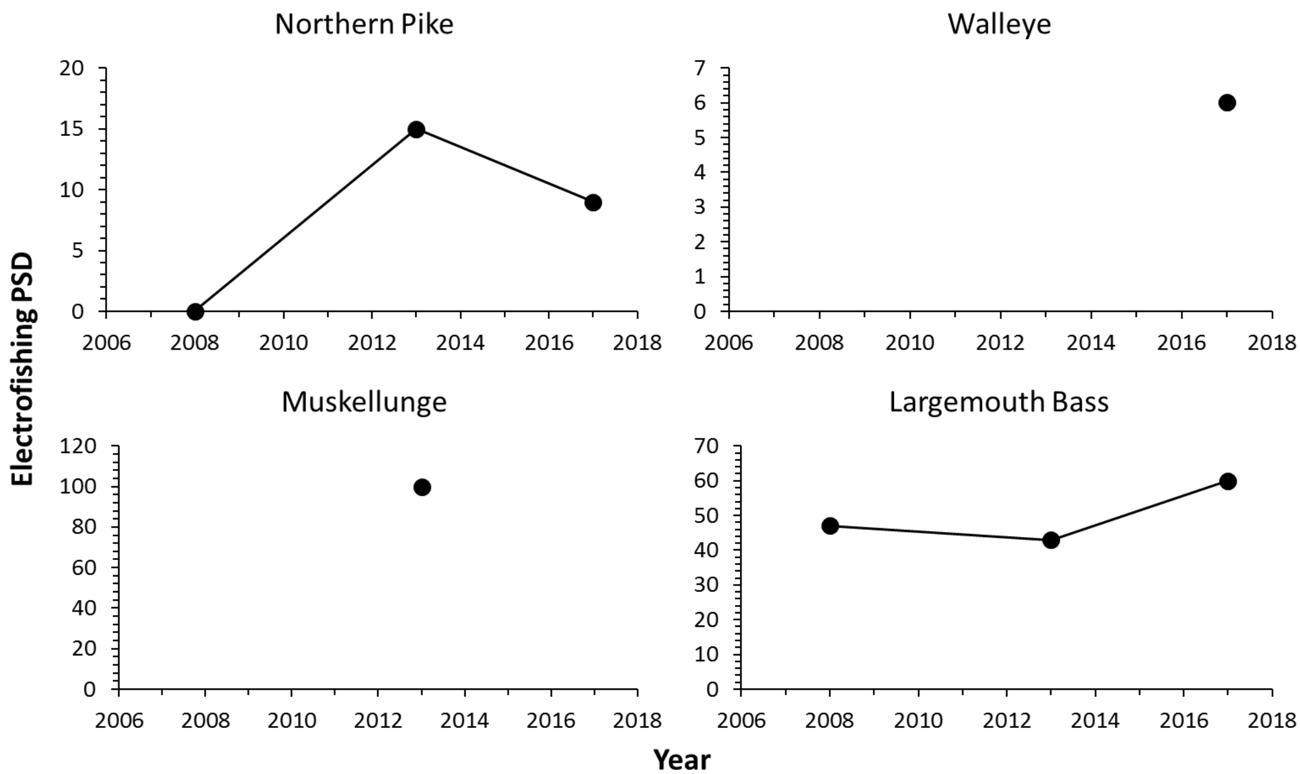

FIGURE 6. Proportional stock density (PSD) values for northern pike, walleye, muskellunge, and largemouth bass captured in spring largemouth bass/panfish electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 2008 – 2017.

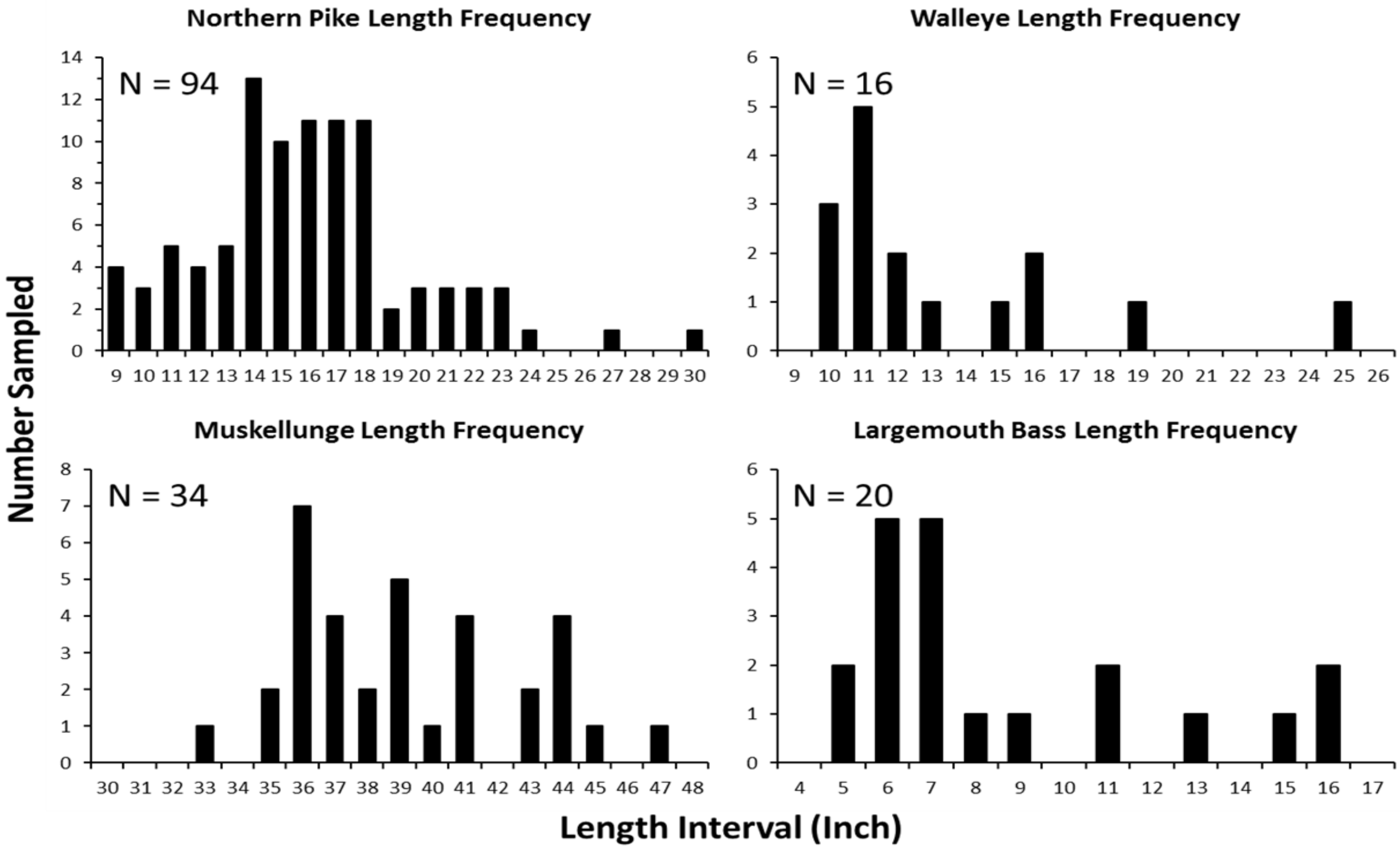

FIGURE 7. Length frequency histograms for northern pike, walleye, muskellunge, and largemouth bass captured in spring, 2017 fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI.

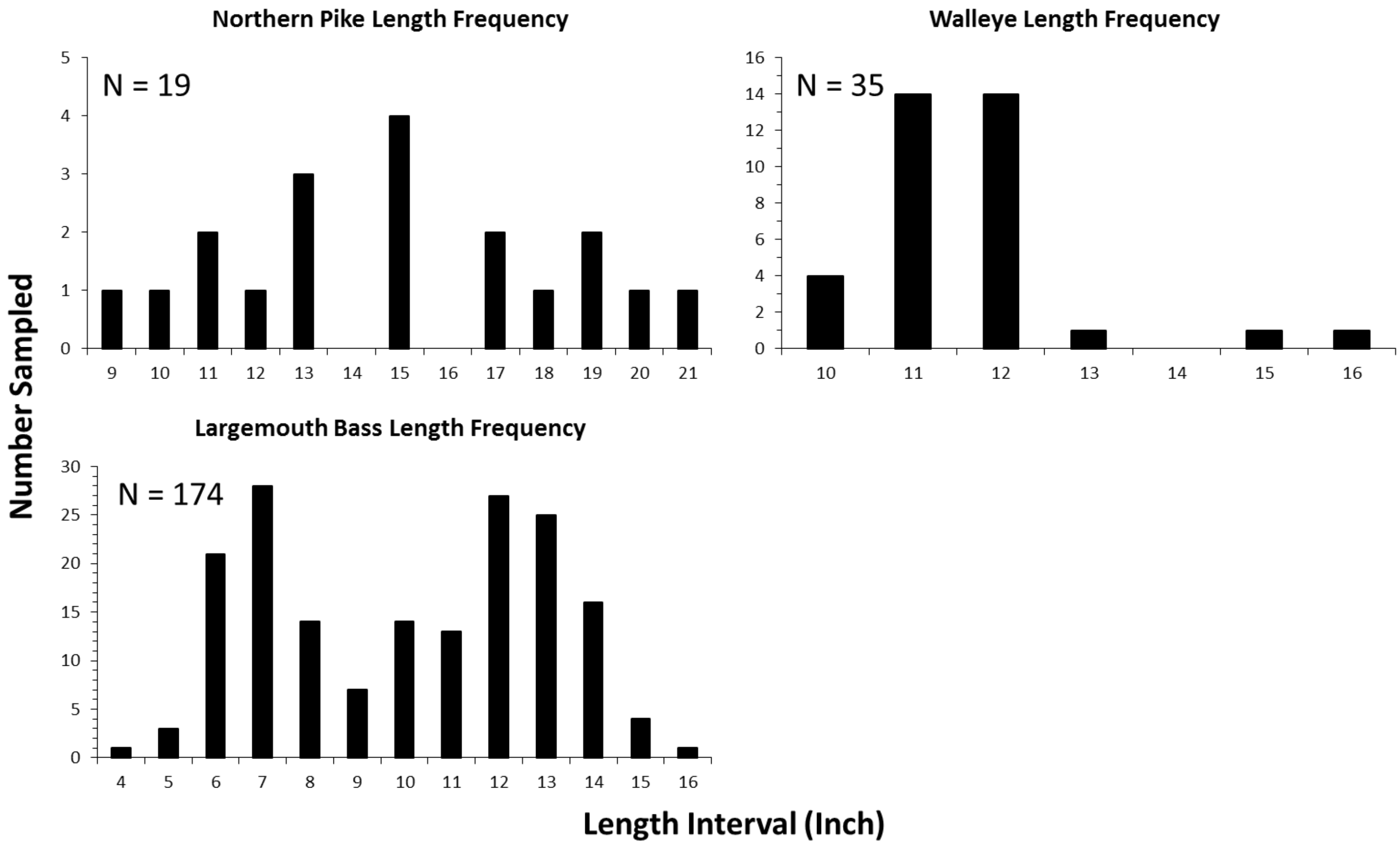

FIGURE 8. Length frequency histograms for northern pike, walleye, and largemouth bass captured in spring, 2017 largemouth bass/panfish electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, WI.

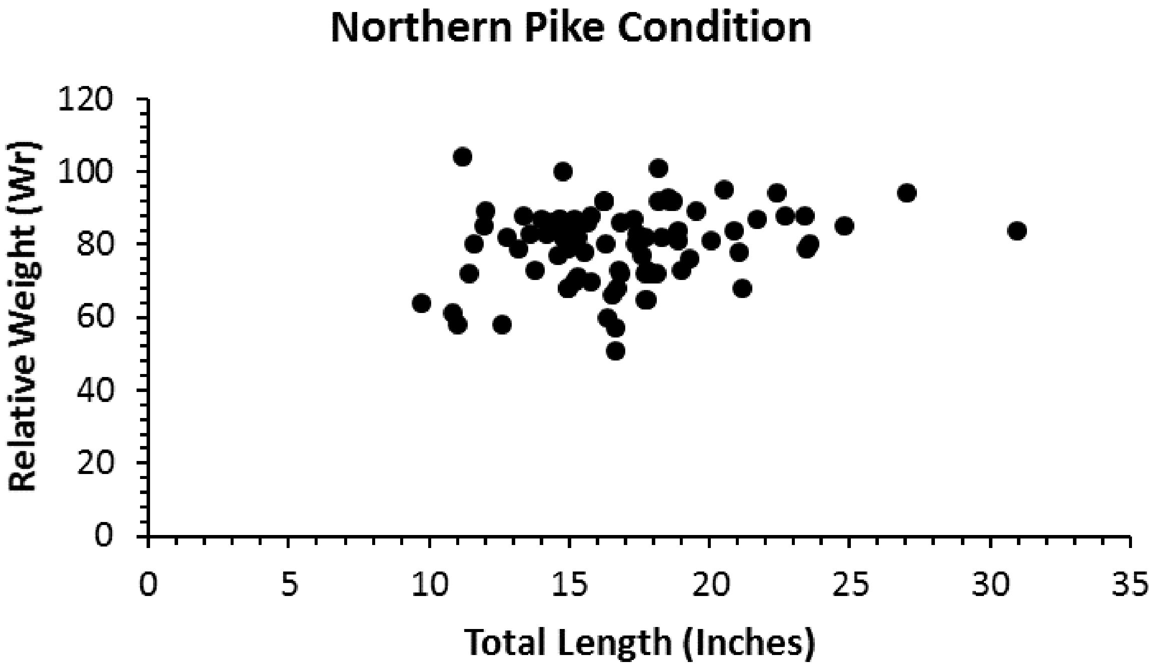

FIGURE 9. Relative weight (W_r) of northern pike captured in the spring, 2017 fyke netting survey of the Cloverleaf Chain of Lakes, Shawano County, WI.

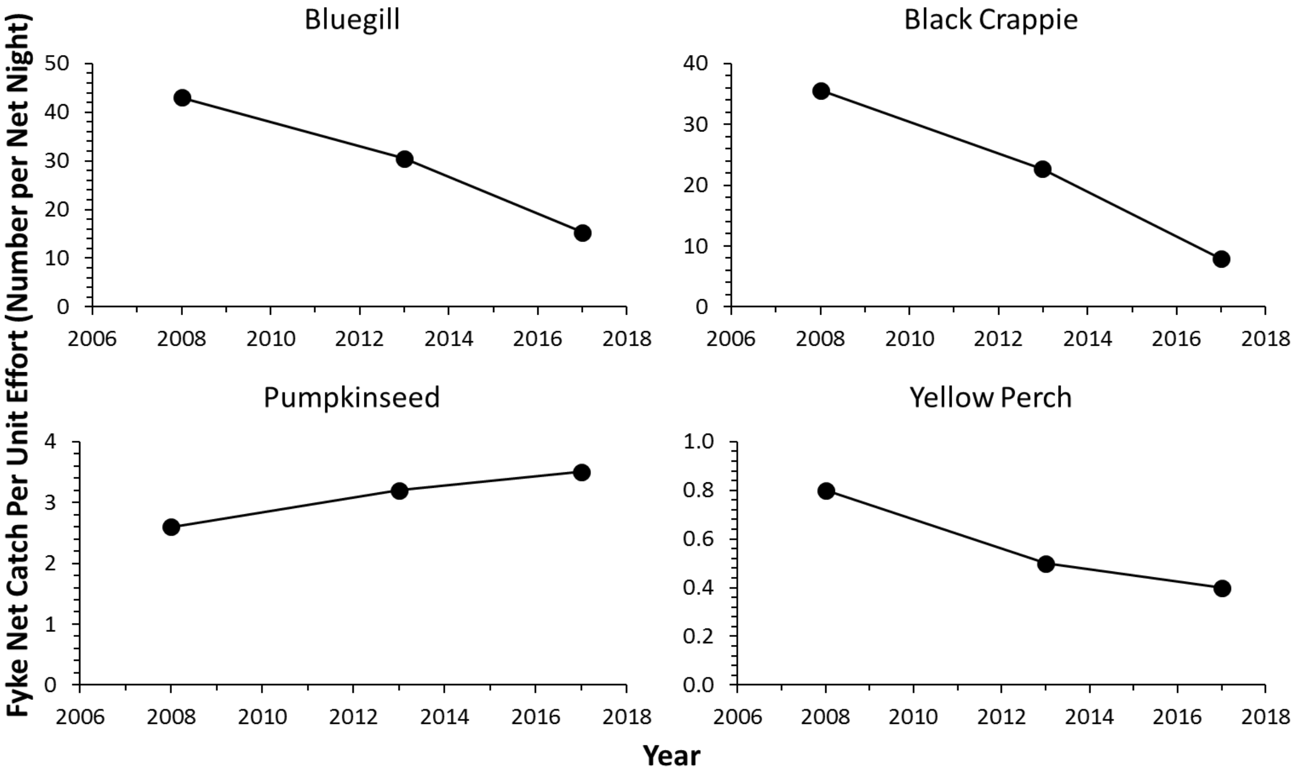

FIGURE 10. Catch per unit effort (CPUE) for bluegill, black crappie, pumpkinseed, and yellow perch captured in spring fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 2008 – 2017.

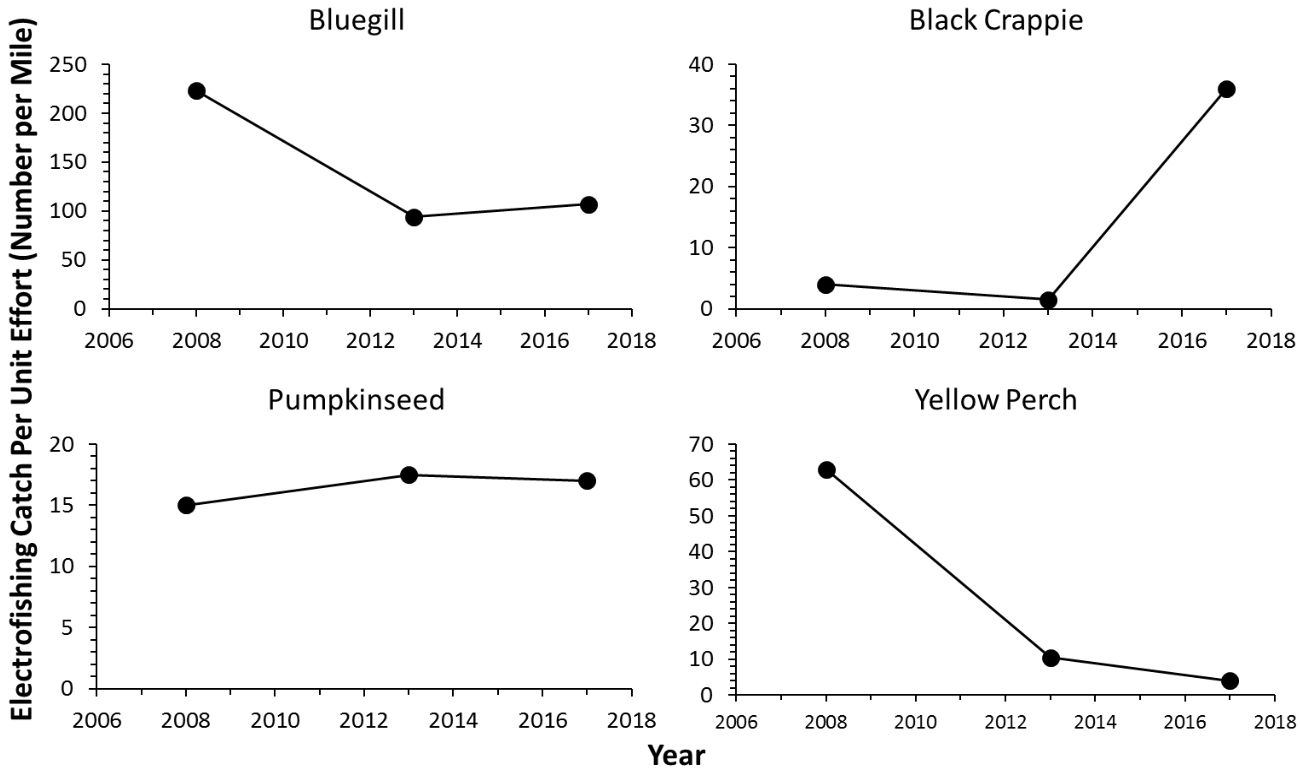

FIGURE 11. Catch per unit effort (CPUE) for bluegill, black crappie, pumpkinseed, and yellow perch captured in spring largemouth bass/panfish electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 2008 – 2017.

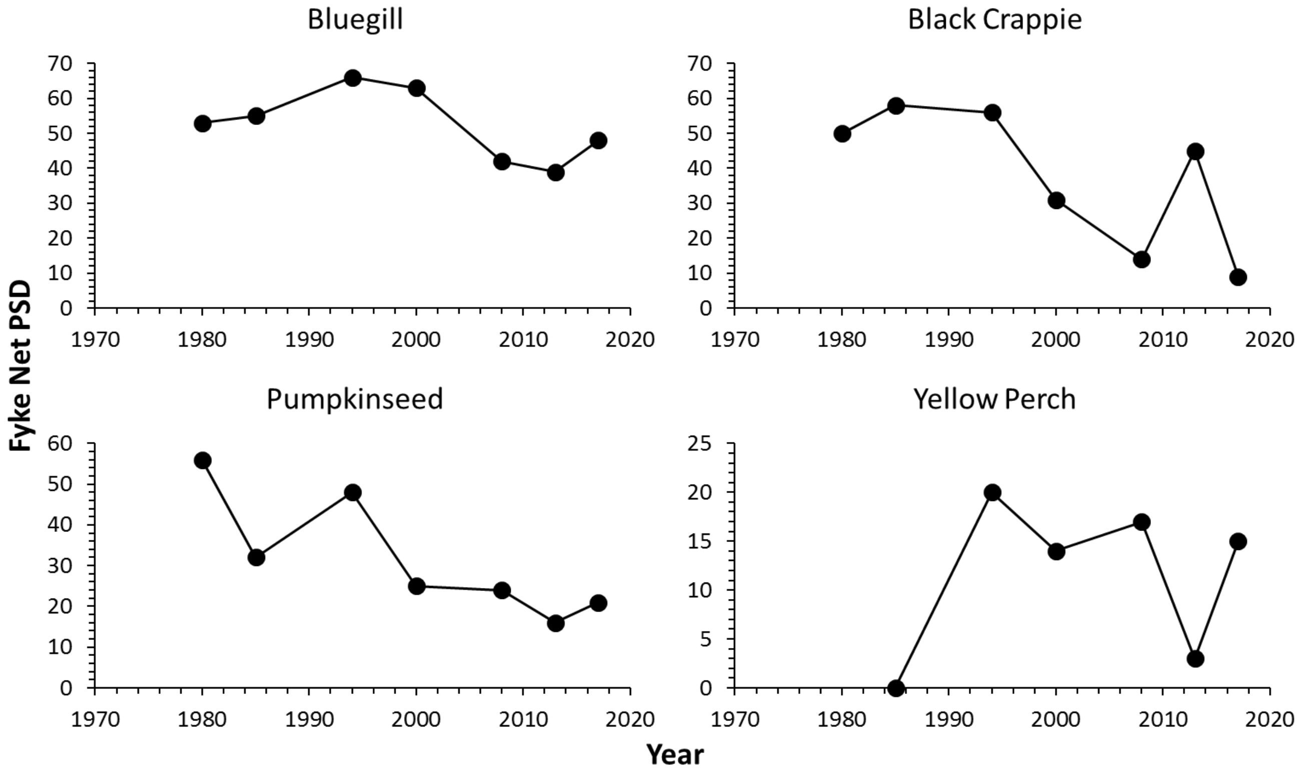

FIGURE 12. Proportional stock density (PSD) values for bluegill, black crappie, pumpkinseed, and yellow perch captured in spring fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 1980 – 2017.

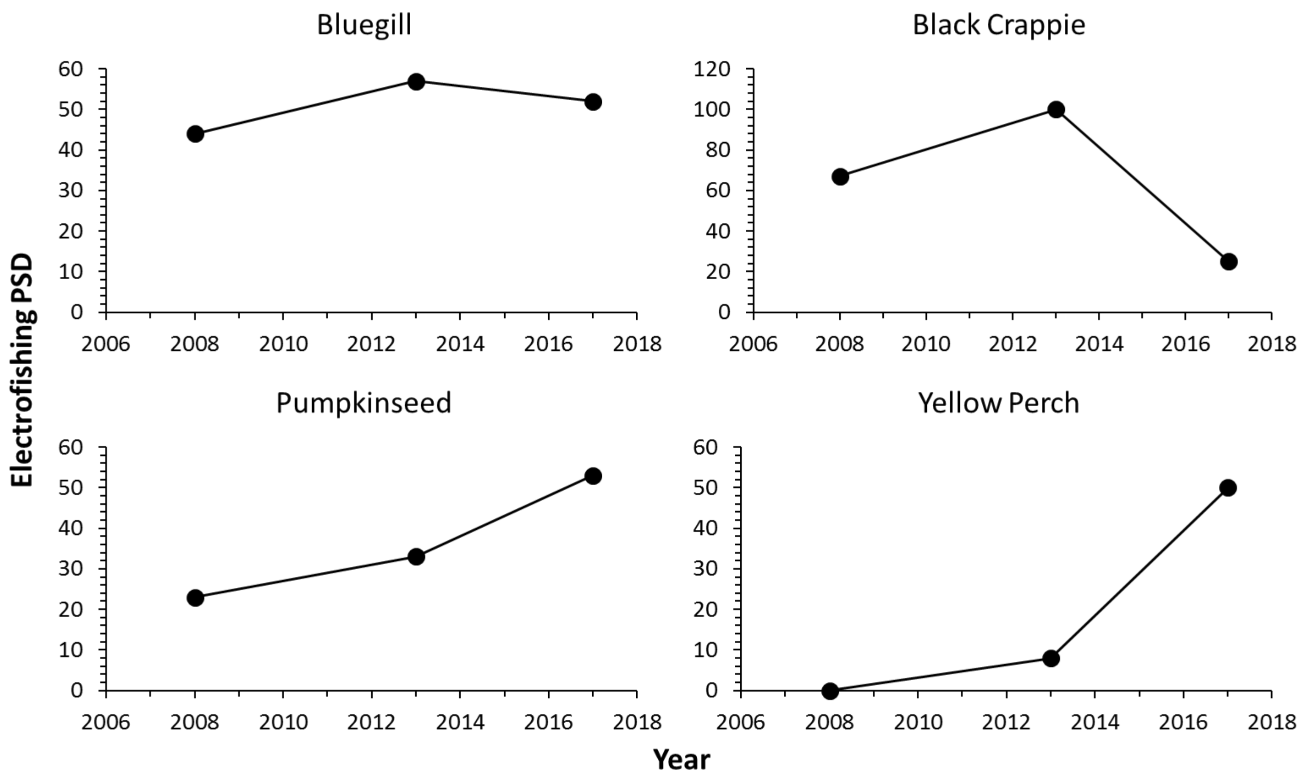

FIGURE 13. Proportional stock density (PSD) values for bluegill, black crappie, pumpkinseed, and yellow perch captured in spring largemouth bass/panfish electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, WI from 2008 – 2017.

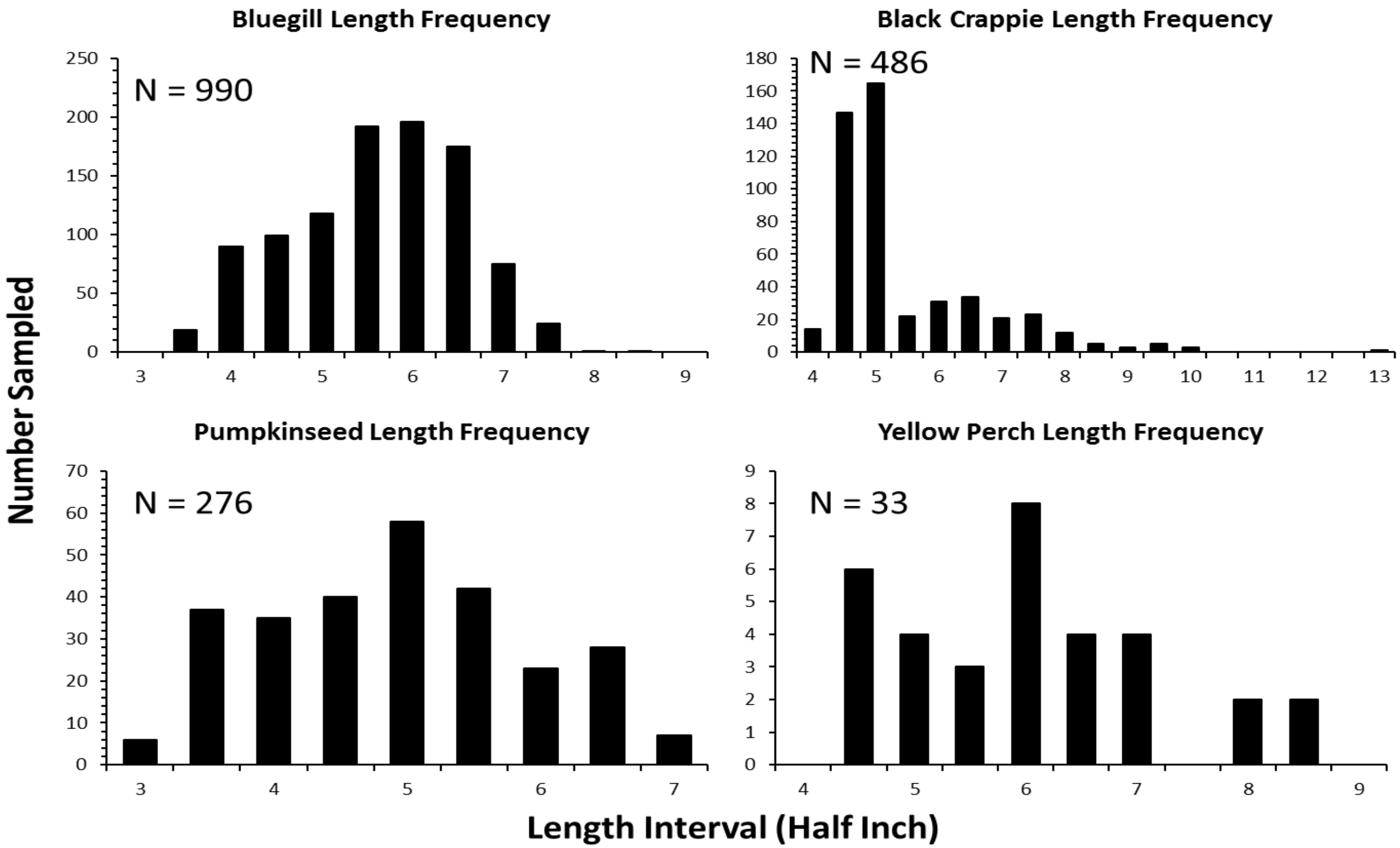

FIGURE 14. Length frequency histograms for bluegill, black crappie, pumpkinseed, and yellow perch captured in spring, 2017 fyke netting surveys of the Cloverleaf Chain of Lake, Shawano County, WI.

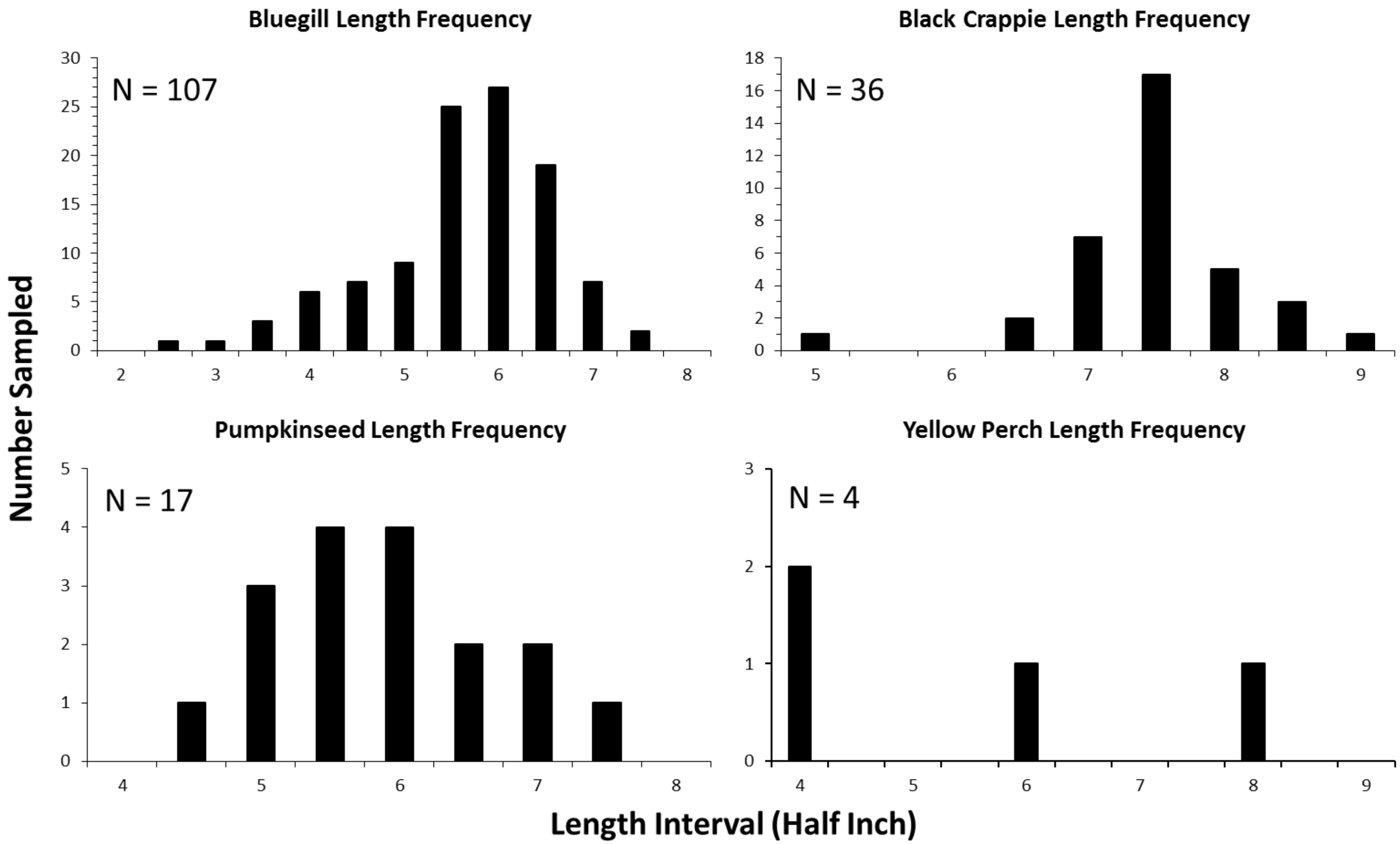

FIGURE 15. Length frequency histograms for bluegill, black crappie, pumpkinseed, and yellow perch captured in spring, 2017 largemouth bass/panfish electrofishing surveys of the Cloverleaf Chain of Lakes, Shawano County, WI.

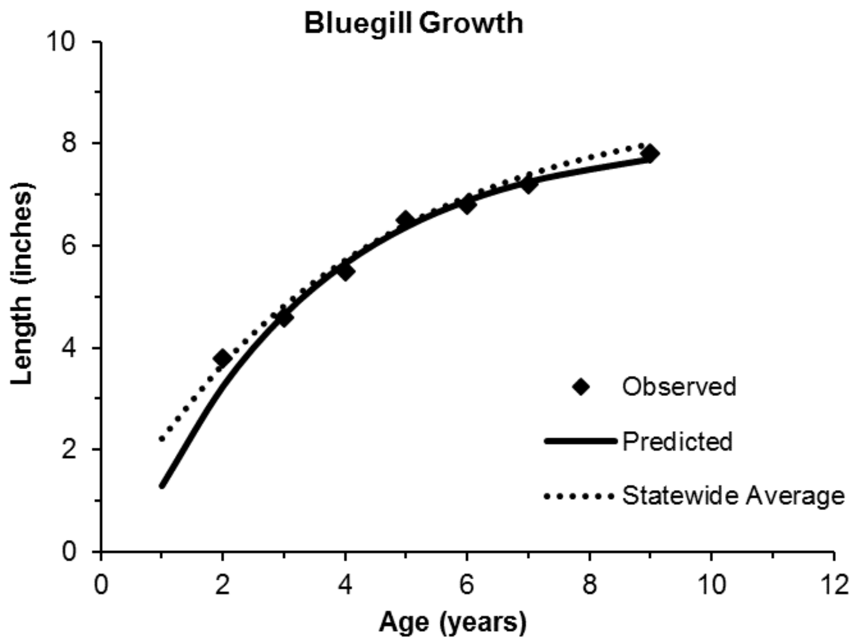

FIGURE 16. Observed (circles) and predicted (line) lengths at age from a von Bertalanffy growth model for bluegill captured during spring, 2017 fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI.

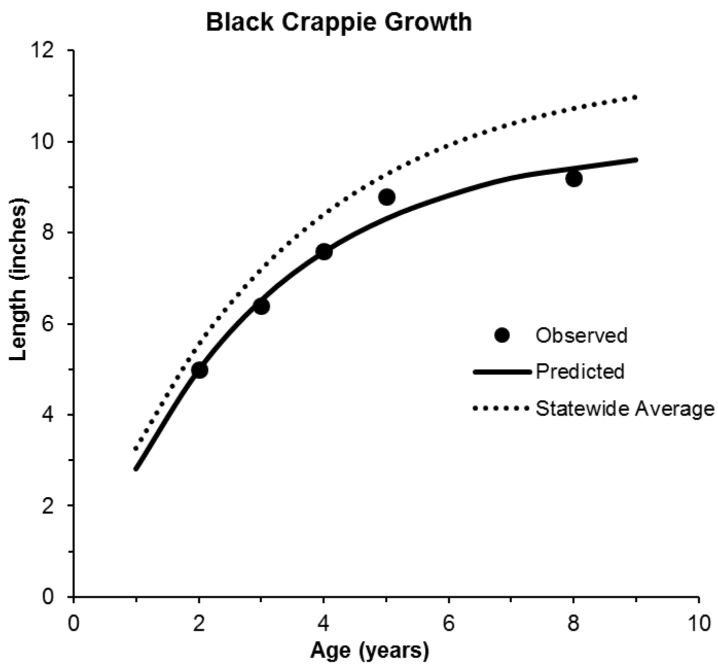

FIGURE 17. Observed (circles) and predicted (line) lengths at age from a von Bertalanffy growth model for black crappie captured during spring, 2017 fyke netting surveys of the Cloverleaf Chain of Lakes, Shawano County, WI.